MINING METHODS AND COSTS, STANDARD URANIUM CORP., BIG BUCK MINE, SAN JUAN COUNTY, UTAH

BY W. L. DARE AND R. R. DURK

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W. L. Dare[1] and R. R. Durk[2]

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INTRODUCTION AND SUMMARY

This information circular is one of a series the Bureau of Mines plans to publish describing the methods and costs of mining uranium on the Colorado Plateau.

The Big Buck mine is one of the larger underground uranium-vanadium ore mines on the plateau. The mine is about 39 miles southeast of Moab in the Big Indian mining district, San Juan County, Utah. The Big Buck claims were located late in 1947, when uranium mineralization was discovered in the Cutler formation at its outcrop along the escarpment that forms the west side of Big Indian Wash.

Charles A. Steen made the first major discovery of uranium ore in the Chinle formation in the Big Indian mining district on July 6, 1952, when 14 feet of high-grade uranium ore was encountered in a diamond-drill hole drilled on his Mi Vida claim. The Big Buck ore body now being mined by Standard Uranium Corp. is a southeast extension of Steen's original discovery.

Standard Uranium Corp. completed an initial exploratory drilling program on the Big Buck claims during the first 3 months in 1954. The drilling program proved the existence of a large, tabular, roughly rectangular ore body which strikes about N. 35° W., dips gently southwestward, and averages about 10 feet thick over a major extent of its area.

The physical characteristics of the ore body and the topography permitted developing the ore body by a 2,000-foot adit that was driven about 100 feet below the ore horizon. The adit is connected to the stope level by a system of near-vertical ore passes and an incline for passage of personnel, equipment, and supplies. Preparation of the mine plant site was begun in May 1954, and the adit was begun early in July 1954. The first ore mined was shipped on February 2, 1955.

A regularly spaced room-and-pillar system of mining is employed at the Big Buck mine. The main rooms or haulageways are about 20 feet wide on 40-foot centers laid out to roughly parallel the long dimension of the ore body. The transverse rooms are also 20 feet wide but are on 70-foot centers. The pillars average 20 by 50 feet.

The thickness, size, and low dip of the ore body are suited to mechanized trackless mining. Development layout and the operational phases of mining are matched to the capabilities of a model 46 Gismo loader and a similarly designed drill jumbo. The Gismo loader was developed by American Zinc, Lead & Smelting Co. under the direction of Dale I. Hayes at the Grandview mine in Washington. Powered by an Eimco, model 105, crawler tractor, the Gismo operates both as a loader and as a transport. The drill jumbo was designed and built by the company along the lines of the loader unit and consists of four rock drills, each controlled independently on hydraulically operated extensible booms. The ore is transported on the adit haulage level by a 6-ton Mancha diesel locomotive and Granby-type mine cars.

Pillar recovery is important and was considered in development planning. The company is confident that their plan of recovering pillars will result in a high percent extraction of the ore. Pillar recovery is planned in two stages; first recovering a maximum number of pillars while working within the stoped area and later working from beneath the stoped area to extract the remaining ones.

Production from the Big Buck mine through February 1956 has amounted to 96,537.75 tons of uranium-vanadium ore.

ACKNOWLEDGMENTS

The cooperation and assistance given by the management and staff of the Standard Uranium Corp. toward preparation of this information circular is gratefully acknowledged. Special acknowledgment is given to William R. McCormick, president and general manager, who gave his time and assistance freely. Ross H. Eddington, mine foreman; Dewey T. Sullivan, safety engineer; Charles H. Edwin, mine engineer; Harry I. Jordan, master mechanic; James Manley, night shift boss; Jack Van Noy, day shift boss; and James B. King, Jr., office manager, were particularly helpful in providing data and details of the mining operation.

LOCATION AND PHYSICAL FEATURES

Claims owned by Standard Uranium Corp. are in secs. 2, 11, 12, 13, and 14, T. 30 S., R. 24 E., Salt Lake meridian, San Juan County, Utah. Most of the area covered by the claims is in sec. 11. The Big Buck mine is reached from Moab, Utah, by traveling southeast 30.2 miles on paved U. S. Highway 160 and then 7.6 miles east on an improved ore-haulage road (see figs. 1 and 2). This access road travels generally south and east over about 6 miles of flat country before turning northeast and entering Steen Canyon. The mine plant and portal of the adit are on the southeast wall of the canyon about 100 feet above the canyon floor. The mine is about 1,800 feet southwest of the Utex Exploration Co. Mi Vida mine and 1-1/2 miles southwest of Big Indian Wash.

Topography in the area is typical of the semidesert Colorado Plateau, with the drainage forming rugged, steep-walled canyons and washes bordered by means locally capped with cliff-forming sandstones. Altitudes in the immediate area range from 6,300 to 7,100 feet above sea level. The La Sal Mountains are about 13 miles north with Mount Peale rising to 12,721 feet above sea level.

Vegetation is sparse and is limited to juniper, pinon pine, and sage brush. The climate is arid. Winter snowfalls are usually about 6 inches deep but may accumulate to as much as 2 feet. Summer rains occur mostly as heavy downpours, sometimes causing local flash floods. Temperatures in the summer rise above 100° F. and fall to below freezing in the winter. There are no perennial streams in the area, and water for mining and camp use is hauled from local wells.

HISTORY AND PRODUCTION

The earliest known uranium mining in the area began in about 1904 in the old Dry Valley mining district about 6 miles southeast of the Big Buck mine. The history of mining in the Dry Valley mining district follows the pattern of the history of uranium mining on the Colorado Plateau as a whole. Initially, the carnotite-type ores found in the Salt Wash member of the Morrison formation were mined for their radium content. Intermittent production for vanadium continued from World War I through World War II. Mining during the third period has continued since about 1946, principally because of the demand of the uranium in the ores.

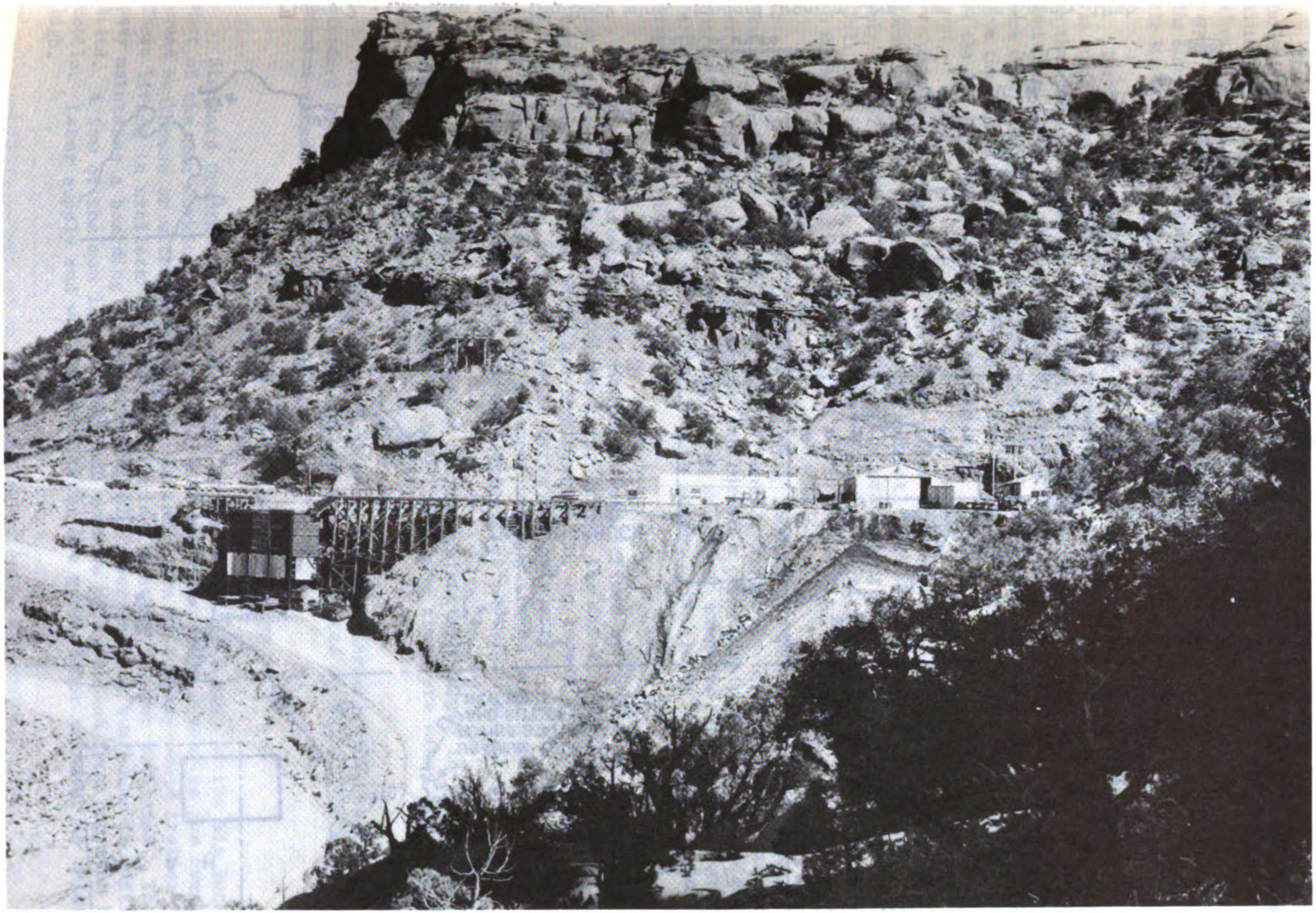


Figure 1. - View looking northeast toward Big Buck surface plant on southeast side of Steen Canyon. The massive cliff-forming sandstone is the Wingate, with the Chinle formation beneath forming the slope.

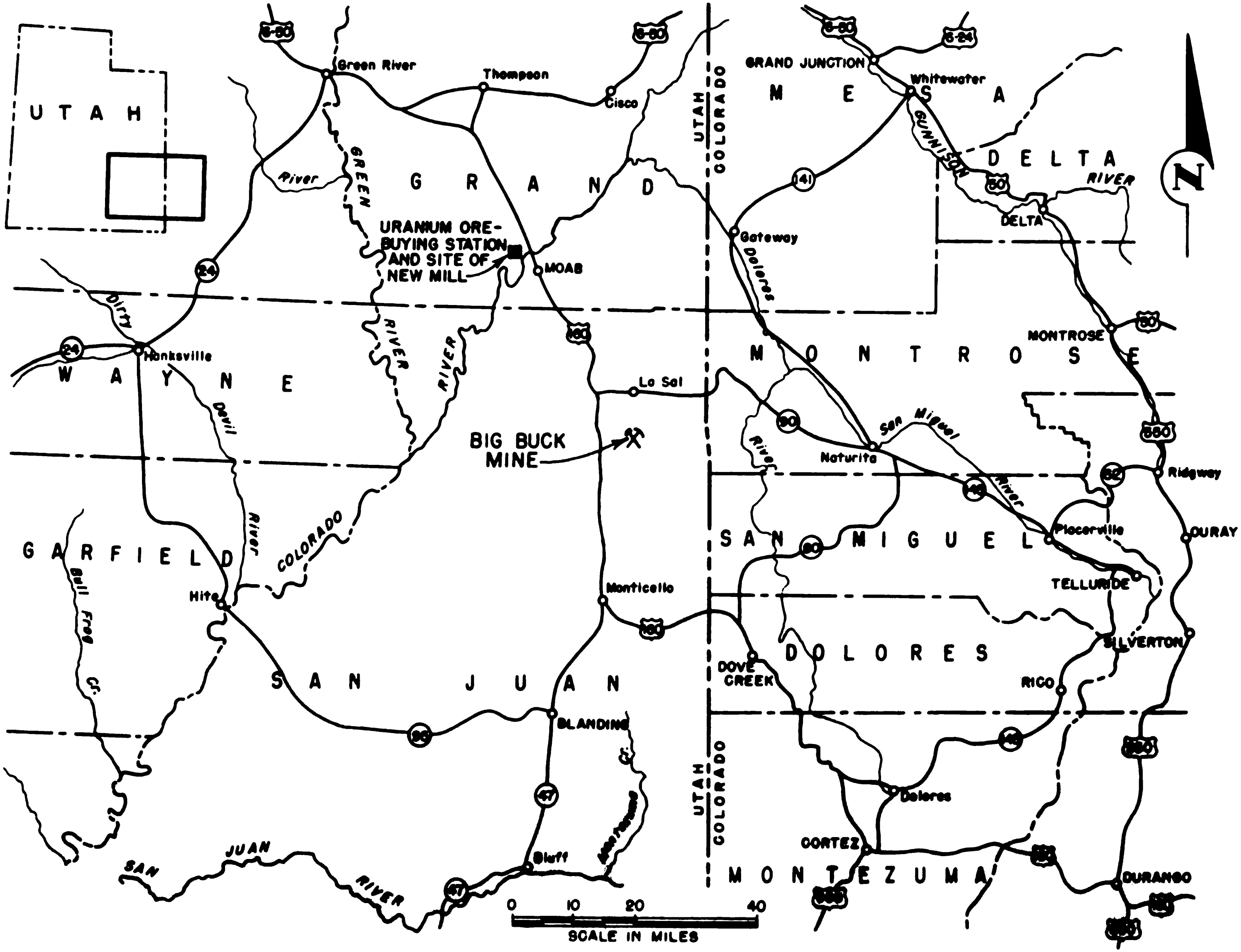


Figure 2. - Location map, Big Buck mine, Standard Uranium Corp., San Juan County, Utah.

The earliest known mining in Big Indian Wash began in about 1908 for copper. Oxidized-copper ores, occurring in sandstones and conglomerates of the undifferentiated Burro Canyon-Dakota formations, were mined from a number of small deposits along the downthrown side of the Lisbon Valley fault. The principal producers of copper ores were the Big Indian mine about 4 miles north of the Big Buck mine and the Blackbird mine about 7-1/2 miles southeast. Copper ore was last produced from the Big Indian mine during World War II by Ohio Copper Co.

The first known mining of uranium-vanadium ores from the Chinle formation in the area began in 1917, from the Serviceberry and Divide mines. These two mines are on the upthrown side of the Lisbon Valley fault along the extension of the escarpment that forms the west side of Big Indian Wash about 7 miles southeast of the Big Buck mine. Sporadic production from the Cutler formation, from 1948 to 1955, came from the old Big Buck workings and from the Small Fry and Purple Paint mines north of the Big Buck mine along the escarpment.

Charles A. Steen made the first major discovery of uranium ore in the Chinle formation in the Big Indian mining district. Steen's initial discovery was on July 6, 1952, when 14 feet of high-grade uranium ore was encountered in a diamond-drill hole on the Mi Vida claim. The first production from the Mi Vida mine was on December 6, 1952.

The Big Buck claims (see fig. 3) were located in 1948 by Donald Hayes of Moab, Utah, in partnership with James Bentley and J. W. Brewer. Hayes bought out his partners' interest in the same year and formed a partnership with Donald Adams of Monticello, Utah. The second partnership was later expanded when a 5-percent interest was sold to Edward Saul and to Joseph Adams. The claims were sold to Standard Uranium Corp. in July 1954.

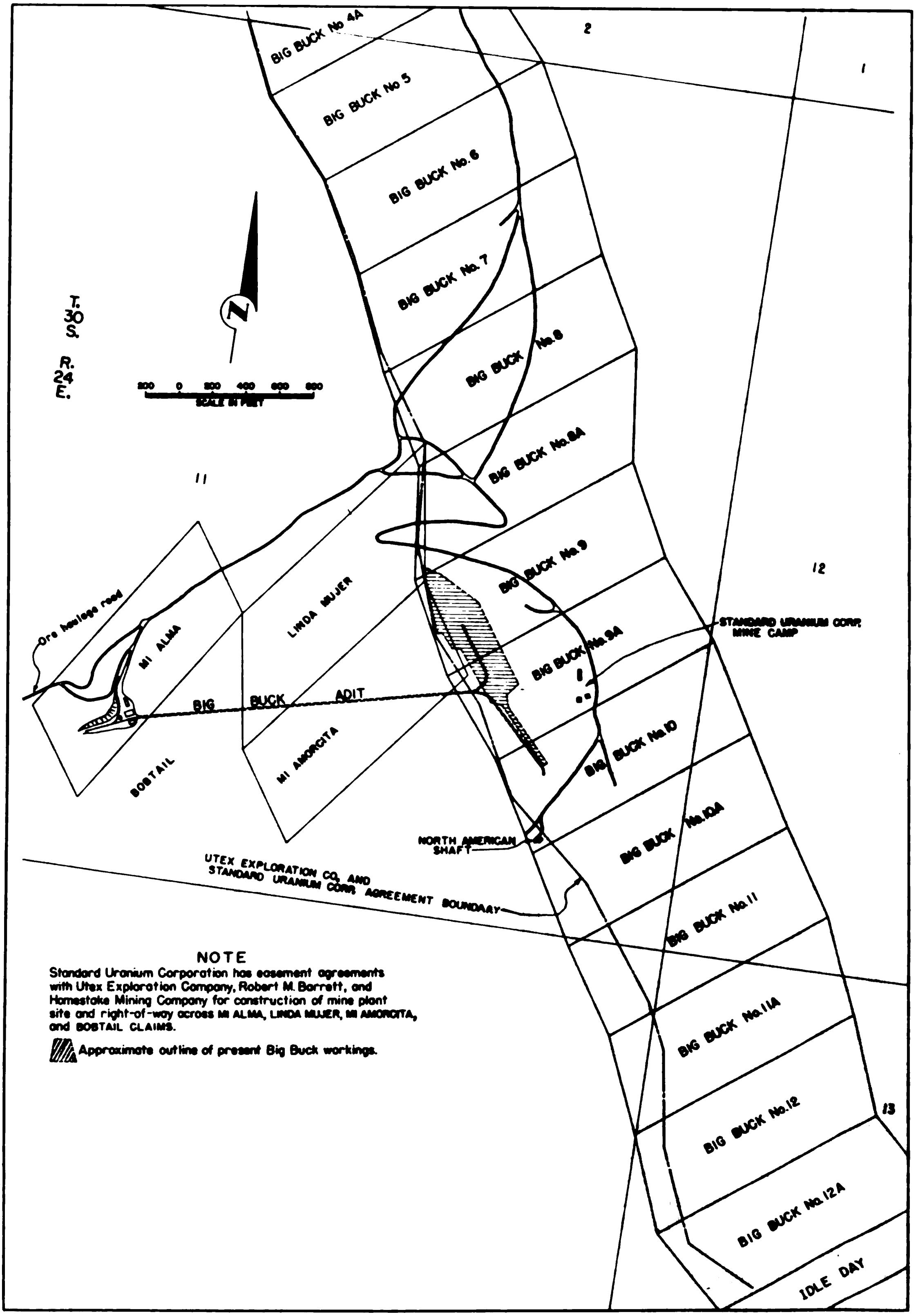
The Big Buck ore body was discovered and defined by the initial drilling program completed by Standard Uranium Corp. during the first 3 months in 1954. An easement was negotiated with Utex Exploration Co. to locate the mine plant on the Mi Alma claim with a right-of-way to drive the adit across the Mi Alma, Linda Mujer, and Mi Amorcita claims. Another easement was negotiated with Robert M. Barrett and Homestake Mining Co. to drive the adit across the Bobtail claim.

Initial bulldozing for preparing the mine plant site began in the middle of May 1954, and the adit was begun in July 1954. The first ore mined from the Big Buck mine was shipped on February 2, 1955.

Total production from the Big Buck mine through February 1956, as released by Standard Uranium Corp. to its stockholders, has amounted to 96,537.75 tons of uranium-vanadium ore.

LABOR AND LIVING CONDITIONS

Standard Uranium Corp.'s, mine camp is about 1/2 mile east of the Big Buck mine. Most of the men working at the mine live at the mine camp, either in the company-owned bunkhouse or with their families in their own or company-owned trailer houses. Those living in trailers are charged a nominal monthly fee for utilities. The company maintains a boarding house, charging $2.75 per day for bunkhouse facilities and board. A few of the men live in Moab and commute daily to and from the mine by automobile. Labor supply and working conditions are good; labor turnover is relatively high.



NOTE

Standard Uranium Corporation has easement agreements with Utex Exploration Company, Robert M. Barrett, and Homestake Mining Company for construction of mine plant site and right-of-way across MI ALMA, LINDA MUJER, MI AMORCITA, and BOBTAIL CLAIMS.

▨ Approximate outline of present Big Buck workings.

Figure 3. - Big Buck claim group, Big Indian mining district, San Juan County, Utah.

GENERAL GEOLOGY AND DESCRIPTION OF DEPOSIT[3 4 5]

General Geology

The Big Indian mining district follows the general trend of the Lisbon Valley anticline (see fig. 4). Lisbon Valley is on the collapsed portion of the northwest plunging anticline, and Big Indian Wash is on the southwest limb. Big Indian Wash is separated from Lisbon Valley by the Lisbon Valley fault and a hogback of the undifferentiated Hermosa and Rico (Pennsylvanian) formations. The Lisbon Valley fault strikes northwest, paralleling the axis of the anticline and passing through the north end of Big Indian Wash. The fault displaces the Hermosa limestone (Pennsylvanian) on the southwest side against the Dakota sandstone (Cretaceous) on the northeast or downthrow side.

Formations exposed in the Big Indian mining district range from the Hermosa-Rico formations (Pennsylvanian) to the Mancos shale (Cretaceous). The formations exposed along the west escarpment of Big Indian Wash are the Cutler (Permian), Chinle (Triassic), and Wingate (Triassic). Uranium mineralization has been found in both the Cutler and Chinle formations.

The Cutler formation in the area is about 880 feet thick, is essentially red, and consists of fine-grained sandstone, discontinuous lenses of coarse-grained arkosic sandstone, siltstone, and mudstone. Small uranium ore bodies occurring in the arkosic sandstone lenses have been mined at the old Big Buck mine, Small Fry mine, and Purple Paint mine. The Chinle formation in the area is about 400 feet thick, forms slopes, and is variable in color. The Chinle formation consists predominantly of red and green mudstones and siltstones interbedded with conglomerates and fine-grained, crossbedded sandstones. The Wingate formation is a massive, red, cliff-forming sandstone 350 feet thick which caps most of the higher areas immediately west of Big Indian Wash. The beds exposed in the vicinity of Steen Canyon dip from 8° to 10° southwest.

Description of Deposit

The Big Buck ore body occurs within the ill-defined basal member of the Chinle formation or in what is called the Moss Back sandstone. This basal member consists chiefly of gray and greenish-gray sandstone, with lenses of green mudstone, siltstone, and conglomerates. The ore is largely restricted to the lower 30 feet of the Moss Back member, extending to within a few feet of the erosional contact of the Cutler formation. In places the ore extends to the contact or a few feet below into the Cutler. The ore stratum is predominantly a medium-grained sandstone with conglomeratic, mudstone, and siltstone lenses. Mudstone pebbles and minor amounts of carbon trash are distributed through much of the sandstone.

The Big Buck ore body is a southeast extension of the Mi Vida ore body mined by Utex Exploration Co. The ore body on the Big Buck claim group is tabular, roughly

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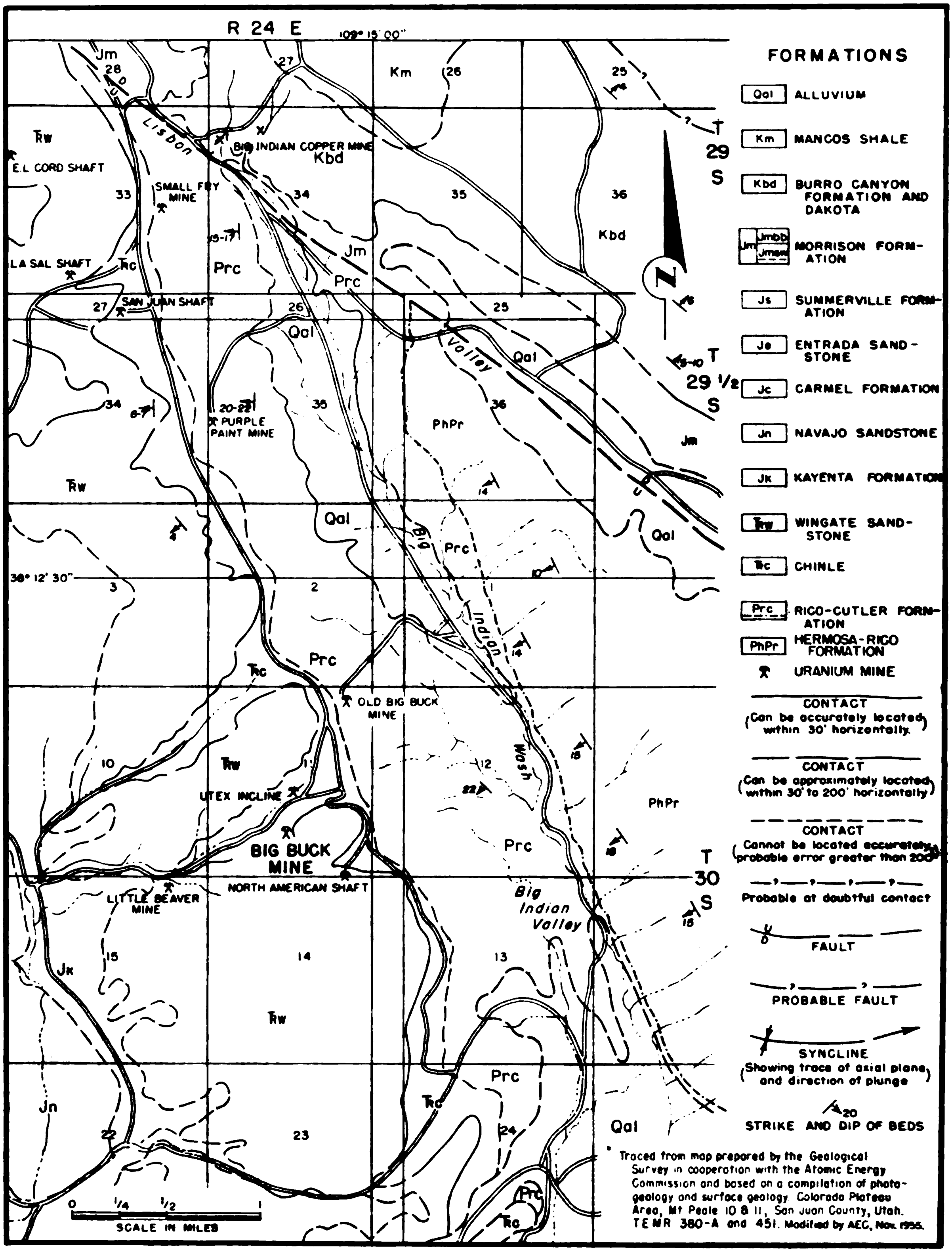
[3] Dix, G. P., Jr., The Uranium Deposits of Big Indian Wash, San Juan County, Utah: Atomic Energy Commission, RME-4022, 1953, 15 pp.

[4] Steen, C. A., Dix, G. P., Jr., Hazen, S. W., Jr., and McLellan, R. R., Uranium-Mining Operations of the Utex Exploration Co. in the Big Indian District, San Juan County, Utah: Bureau of Mines Inf. Circ. 7669, 1953, 13 pp.

[5] Oral communication with AEC geologist at the AEC camp in Big Indian Wash, San Juan County, Utah.



* Traced from map prepared by the Geological Survey in cooperation with the Atomic Energy Commission and based on a compilation of photogeology and surface geology Colorado Plateau Area, Mt Peale 10 & 11, San Juan County, Utah. TEMR 380-A and 451. Modified by AEC, Nov. 1955.

Figure 4. - Geologic map of Lisbon Valley and Big Indian Wash, San Juan County, Utah.

rectangular in shape, with its long dimension striking about N. 35° W. and paralleling the strike of the sedimentary beds. The deposit dips gently southwestward. A major portion of the ore body ranges from 9 to 20 feet in thickness and averages about 10 feet. The thickest ore mined to date has been at the northwest end near the junction with Utex Exploration Co. property. The grade of uranium-vanadium mineralization is fairly uniform throughout the deposit. Along the northeast limit of the ore body, there is a gradual diminishing of the grade of the ore with no appreciable thinning of the host rock, whereas along the southwest side the host rock thins considerably before reaching the ore limit. The principal ore minerals are uraninite and montroseite.

The adit, from its portal to a few feet beyond the incline, has cut the Chinle formation. The incline was started near the base of the Moss Back member and was driven up its apparent dip. Beyond the incline the haulage level is in the Cutler formation.

The thickness, size, continuity, and gentle dip of the Big Buck ore body are the factors that influenced the choice of a room-and-pillar mining method.

METHOD OF EXPLORATION

The Big Buck claim group was explored by drilling vertical holes from the surface. Drilling was contracted by Moab Drilling Co., which used truck-mounted, rotary-type drills. The initial drilling program was completed during January, February, and March 1954 and consisted principally of drilling exploratory holes along the projected extension of the nearby Mi Vida ore body. The Big Buck ore body was established by the initial drilling program, which consisted of 24,941 feet of drilling completed in 69 holes. Subsequent drilling, from October 1954 through April 1955, has amounted to 5,027 feet completed in 19 holes. Drilling depths have ranged from 45 feet to 492 feet with an average depth of 340 feet.

Ore reserves were calculated when the initial drilling program was completed. For tonnage calculations, the ore body was assumed to be a uniformly tapered mass between drill holes and a factor of 14 cubic feet per ton was used. The average grade of U_3O_8 and V_2O_5 was calculated by using the weighted average of all holes within the ore zone. A minimum mining height of 5 feet was established; and when holes indicated thinner ore, the assays were weighted to the minimum height. With the tonnage, grade of ore, and various ore thicknesses determined, it was then possible to lay out a mining program to conform with the shape and character of the ore body.

METHODS OF DEVELOPMENT AND MINING

Development

The Big Buck ore body is developed by an adit haulage level driven below the ore body, a system of near-vertical ore passes connecting the haulage level with the stopes above, and an incline for passage of personnel, equipment, and supplies from the haulage level to the stopes (see figs. 3 and 5). Mine development and the mining techniques employed represent a system of coordinated mining phases that typifies the advance planning that has gone into production of uranium ore from the larger and thicker deposits on the Colorado Plateau. Based on the total tonnage of the ore body and its manner of occurrence, a planned rate of production of 500 tons per day from a 2-shift operation, was decided upon. The methods of development and system of mining were then planned to attain this rate of production.

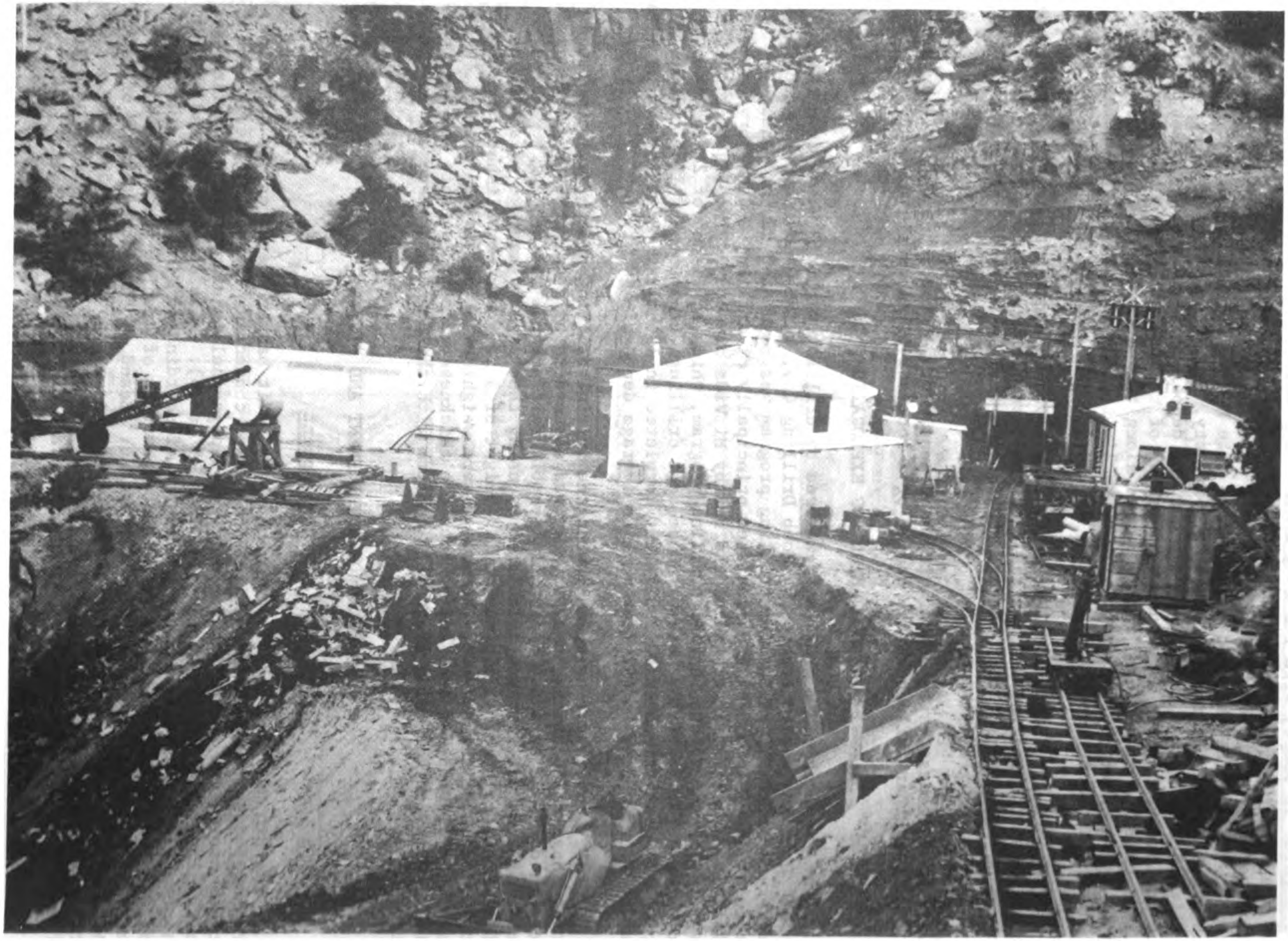


Figure 5. - Big Buck mine surface plant and adit portal.

Topographic features in the area of the Big Buck claim group would have permitted access to the ore body either by sinking a 400-foot shaft about 500 feet east of the ore body or by driving approximately 2,000 feet of adit. The direct cost of sinking a shaft of a size required to hoist 500 tons per day plus the cost required to drive 500 feet of drift was estimated by company management to approximate the direct cost of driving the adit. It was estimated that the initial cost of surface plant installations would be less for an adit operation than that required for a shaft and the operational cost of working through an adit would be less, primarily because of reduced labor costs. The operational flexibility of working through an adit would be advantageous in permitting easy passage of large trackless mining equipment between the surface and the stopes. Driving the adit for access to the ore body was chosen on the basis of ultimate cost saving, flexibility in operation, and pillar extraction.

Since a room-and-pillar method of mining the relatively horizontal ore body was decided upon, development planning had to consider a systematic method of pillar extraction. Gravity ore passes and a haulage level below the ore horizon provide existing workings from which to work safely when recovering pillars. Caving within the stoping area will not damage these lower workings. Choice of a main haulage level below the ore permits use of track-type haulage equipment, thereby eliminating a haulage system adapted to steeper grades and local irregularities of the stope bottom. It also permits underground ore storage as well as gravity-feed-mine-car loading from chute installations. To minimize the number of draw points and installation costs and also to take advantage of existing topographic conditions at the surface for mine plant construction, the haulage level was established about 100 feet below the ore. This difference in elevation permits adequate underground storage capacity, allowing a continuous main haulage cycle, with the fewest number of ore passes.

The portal of the adit is at an elevation of 6,482 feet above sea level on the southeast side of Steen Canyon approximately 100 feet above the canyon bottom. Only the first 50 feet of the adit required timber support. The adit was driven on a bearing of N. 77° E. for 2,000 feet, where it junctions with 2 diverging haulage drifts that were driven in opposite directions and roughly parallel the long dimension of the ore body. The adit is 8 by 9 feet in cross section for the first 1,625 feet or to where the incline was started upward to the ore horizon. From this point the adit and haulage drifts are 6 by 8 feet in section. The northwest haulage drift was driven on a bearing of N. 35° W. and from the rail switch is 490 feet long. The southeast haulage drift was driven on a bearing of S. 43° E. for the first 640 feet and then was turned on a bearing of S. 4° E. and will be continued in this direction to connect with the nonoperating, 3-compartment, North American shaft. The Big Buck southeast haulage drift will intersect the shaft at its sump and the interconnection will assist in ventilating the haulage level.

The location of the switch point was determined as one that would minimize average haulage distance. The haulage level was driven on a 0.5 percent grade.

The haulage level ranges from about 71 to 114 feet below the undulating stope bottom. Three untimbered ore passes connect the 2 levels, though when fully developed 2 additional ore passes will be driven from the southeast haulage drift. The lateral distance between ore passes at stope level is about 240 feet; the incline angles range from 76° to 80°. The center ore pass is roughly 5 by 9 feet in rock section and has a capacity of about 180 tons. The north ore pass is about 6 by 6 feet in rock section, and the south ore pass is about 5 by 5 feet. Total storage capacity of the 3 is about 390 tons.

At a distance of 1,625 feet from the portal, an 8- by 8-foot incline was driven from the adit upward to the ore horizon. The incline is 430 feet long to the point where ore was first contacted. The grade of the incline changes over its length but averages 19.0 percent. The larger cross-sectional size of the first 1,625 feet of the haulage level and that of the incline permits moving large, trackless-type, mining equipment between the surface and the stopes.

Initial bulldozer work in preparing the mine plant site began the middle of May 1954. Work in the adit was begun early in July. From July 1, 1954, to September 1, 1954, although the principal effort went into mine yard excavation and leveling, construction of mine buildings, and installation of equipment, miners, working on company time, advanced the adit 450 feet. The remaining distance was then driven by contact labor who broke four to five 5-foot rounds per day, working on a 3-shift basis. Drilling was done using a track-mounted jumbo that mounted two 3-inch rock drills on independently operated hydraulic extensible booms. Broken rock was loaded into the Granby-type mine cars using an overhead mechanical mucking machine and transported to the portal by the diesel locomotive. The jumbo was later dismantled, and the 2 booms, fitted with 12-foot chain-feed shells, were installed with 2 others on the company-built stope jumbo. Average unit costs for driving the first 2,300 feet of the haulage level are tabulated at the end of this report.

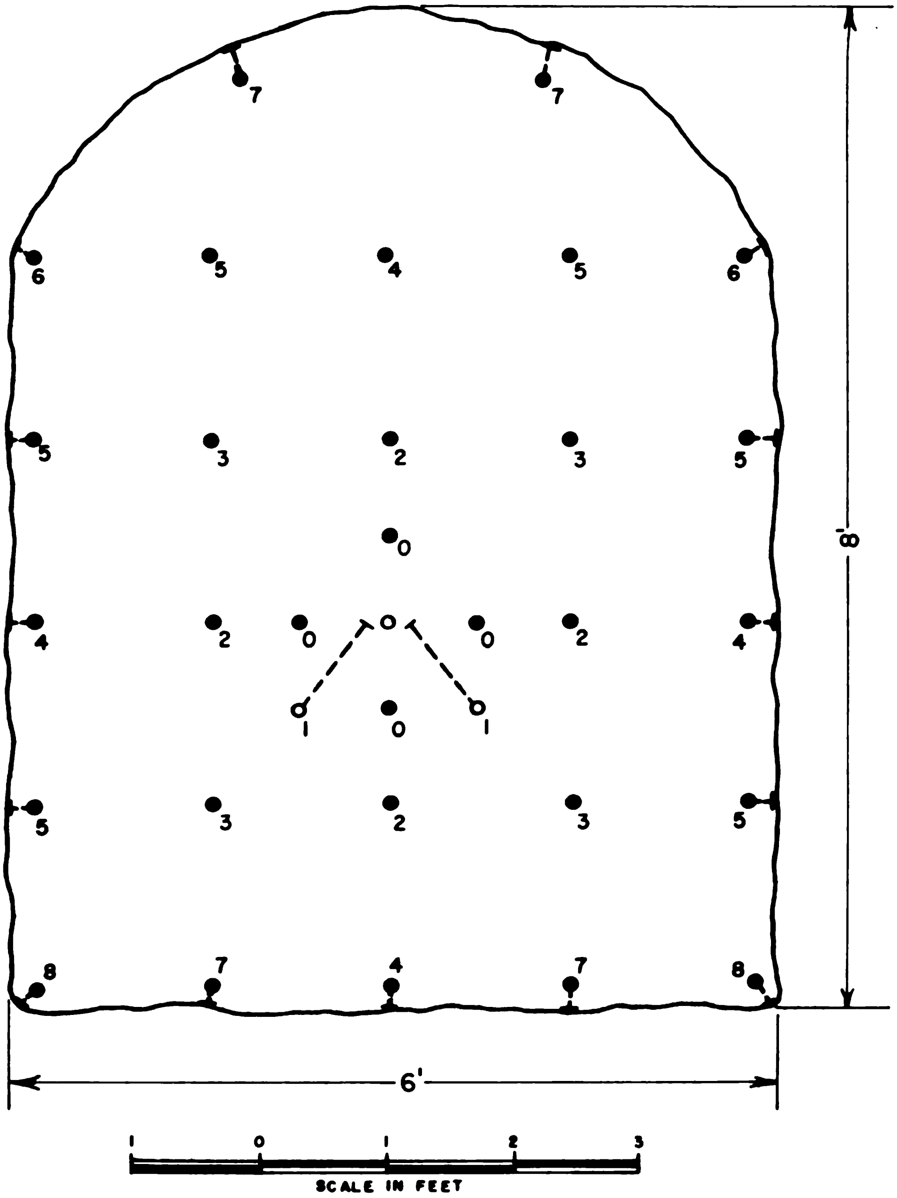
By January 4, 1955, the northwest split of the haulage level was advanced beyond the point where the center raise was to be put up, and the raise was begun; about the same time work was started on the incline.

The center raise was advanced with two compartments, manway and waste chute. It contacted the ore at 91 feet above track level, and the first ore mined from enlarging the initial room was shipped on February 2, 1955. While the incline was being advanced from the bottom, the upper level was being advanced in ore southwest of the raise to meet the incline. In both instances a 10-horsepower, electric, 3-drum scraper hoist and a 42-inch scraper were used for removing ore and waste. The rock from the incline was scraped over a slusher ramp directly into the mine cars on the haulage level. When the incline had been advanced some 230 feet, the efficiency of the scraper decreased, and at a point 220 feet east of where the incline was started a 30-foot waste raise was driven from the haulage level to intersect the incline. The rock was then moved with the Gismo loader to the waste chute. When the junction was made, the timber in the main center raise was removed, and the trackless mining equipment was brought through the incline into the stope.

The southeast haulage drift is now being driven by 2 contract miners working 1 shift per day. The average daily advance is 5.0 feet. Blast-hole rounds are drilled with an air-leg-type drill. The formation is predominantly mudstone, with minor amounts of sandstone. When advancing through tight solid ground, the drift round consists of 33 holes spaced on approximately 1.8-foot centers (see fig. 6). In softer ground the burden per hole is increased by decreasing the number of holes. A 5-hole burn cut is used with 2 reliever holes collared slightly below the lower cut holes and pointed upward to bottom near the center rear of the cut. These two holes are detonated immediately after the cut holes to clean the cut. Regular-delay electric blasting caps are used.

Mining

A regularly spaced room-and-pillar system of mining is employed at the Big Buck mine. Mining to date by Standard Uranium Corp. has been confined to an area approximately 560 feet long and 260 feet wide. Utex Exploration Co. produced ore under



The formation is predominantly mudstone with minor lenses of sandstone. The blast-hole spacing shown is used in tight solid mudstone. Where the ground is softer, the burden per hole is increased by decreasing the number of vertical rows of hole from 5 to 4.
Regular-delay-type electric blasting caps are used, detonated in the sequence of the hole numbers. The center hole of the cut is not loaded. The two sloping reliever holes are collared below the cut and are bottomed near the center rear of the cut. These two holes are detonated immediately after the 4 cut holes to clean the cut.

Figure 6. - 33-hole haulage drift round with a 5-hole burn cut, Big Buck mine, San Juan County, Utah.

contract from the Big Buck 8-A and 9 claims while driving southeast to make the ventilation connection between the Big Buck and Mi Vida mines.

The main rooms or haulageways are 20 feet wide on 40-foot centers, laid out in a northwest-southeast direction and roughly paralleling the longitudinal axis of the ore body. The transverse rooms or haulageways are also 20 feet wide but are on 70-foot centers. The pillars average 20 by 50 feet (see figs. 7 and 8). The rooms are mined to the full height of the ore in 1 or 2 advances. Where the ore is 10 to 15 feet high, it is mined to its full height on the first advance. In thicker ore 10- to 12-foot rooms are first advanced along the top of the ore with the second advance following the bottom. Because of local irregularities at the base of the ore, the bottom is drilled with a jackhammer and the drill cuttings checked to ascertain that the full section of the ore has been mined. Until the limits of the ore body are reached, the entire mine production will come from mining on the advance.

Room-and-pillar mining is adaptable to the thickness, size, and continuity of the Big Buck ore body. Experience at the neighboring Mi Vida mine demonstrated that 20-foot spans of unsupported back are safe. The 20-foot rooms were also considered as near optinum size for the efficient operating capabilities of the type of drilling and loading equipment used. Company management believes that the 20-foot spans of unsupported back will keep the rock above the span tighter than if the rooms were wider, insuring greater safety when initial pillar extraction begins. The back stands well, although there is minor sloughing from mustone strata that lay above much of the ore. These areas are roof bolted.

The thickness, size, and gentle dip of the deposit are suited to mechanized trackless mining. The operational phases of mining are matched to the capabilities of a model 46 Gismo loader and a similarly designed drill jumbo. The Gismo loader unit is powered by an Eimco, model 105, crawler tractor, which together operate as a loader and transport. The Gismo was developed by American Zinc, Lead, & Smelting Co. at the Grandview mine in Washington under the direction of Dale I. Hayes. Before development work was begun at the Big Buck mine, Robert R. Durk, superintendent, visited the Grandview operation to study the performance of this machine and to learn of operating conditions that permit maximum efficiency in its use.

Drilling and Blasting

The drill jumbo consists of 4 percussion rock drills mounted on 12-foot shells, each positioned independently on hydraulically operated extensible booms (see figs. 9 and 10). The single-unit jumbo frame was designed by the company and was built at the mine shop along the lines of the Gismo loader unit. It was put into operation in January 1956. The frame is built of welded 3/4-inch structural steel plate, the sides tapering to a "V" at the rear of the frame, terminating at a large vertical pin. When drilling, the rear of the jumbo rests on the pin adding stability to the drill platform. To move the jumbo the pin is coupled to the tractor that motivates the Gismo loader and set at a face to be drilled in the same manner as when the loader unit is being positioned. The V-shape frame construction near the coupling pin permits the tractor operator to turn the drill jumbo at near right angles to the tractor, which assists its positioning within a limited space. The drill jumbo is usually positioned about 10 feet from the face to be drilled. The jumbo is axle-mounted on dual 15-inch wheels and 7.50- by 15-inch, 10-ply tires. The extensible booms, actuating cylinders, and hydraulic system are standard equipment of the Joy Manufacturing Co. model DJA drill jib assembly. The hydraulic piston pump, compressed-air drive motor, and hydraulic fluid reservoir tank are mounted in the center of the jumbo, which corresponds to the hopper on the Gismo loader. The hydraulic

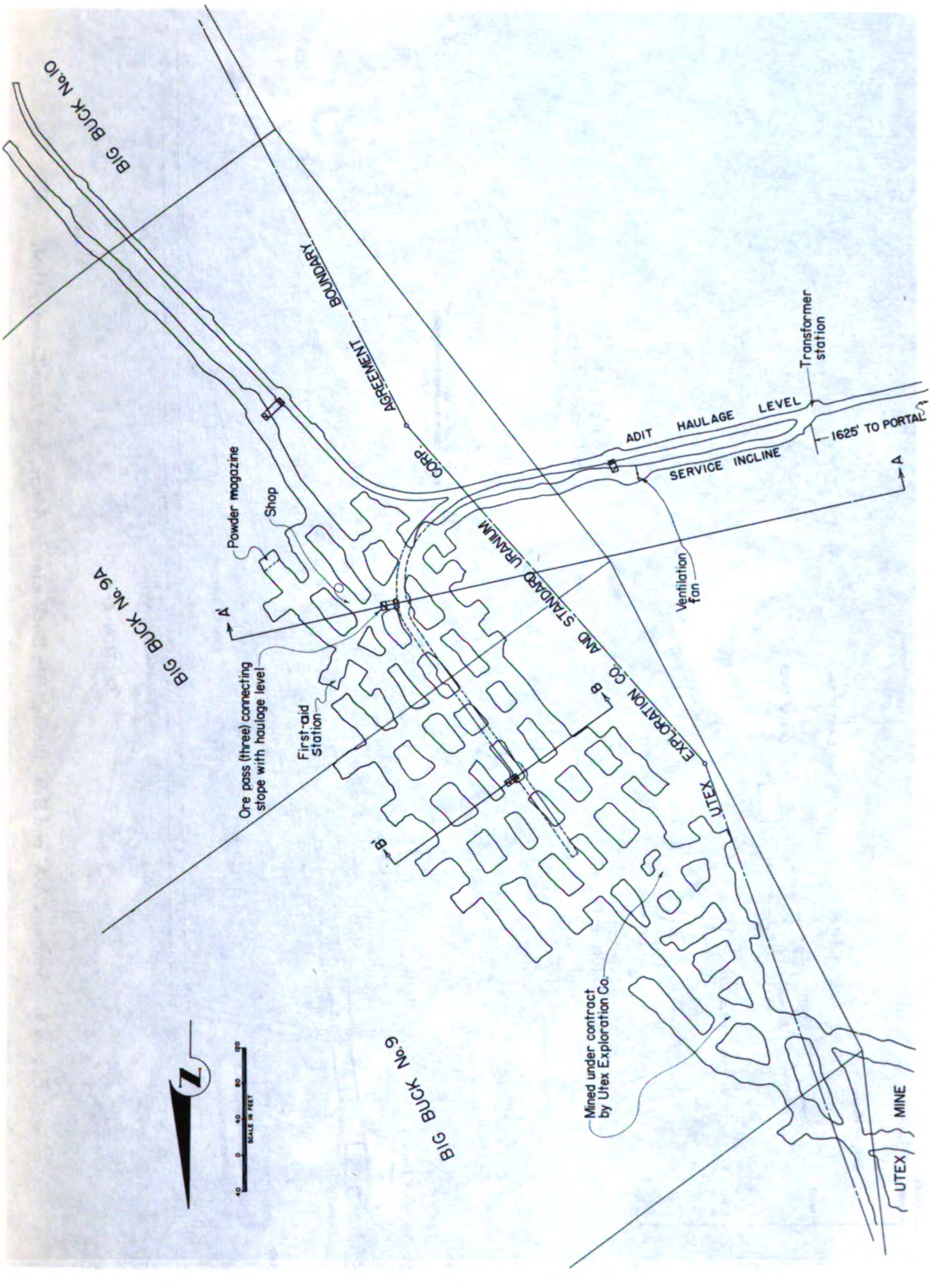


Figure 7. - Plan map, underground workings, Big Buck mine, San Juan County, Utah.

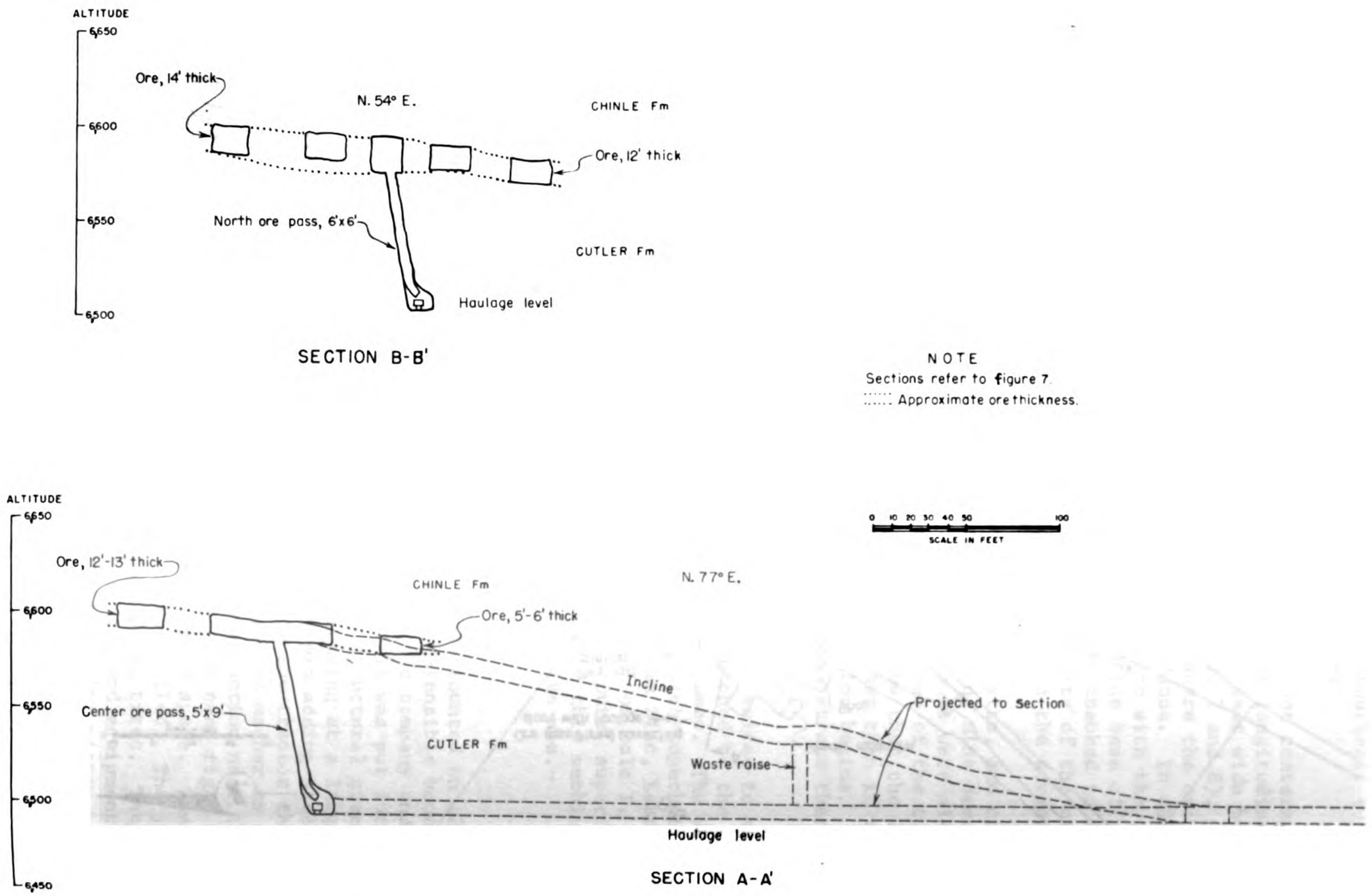


Figure 8. - Sections A-A' and B-B' through Big Buck mine workings, San Juan County, Utah.

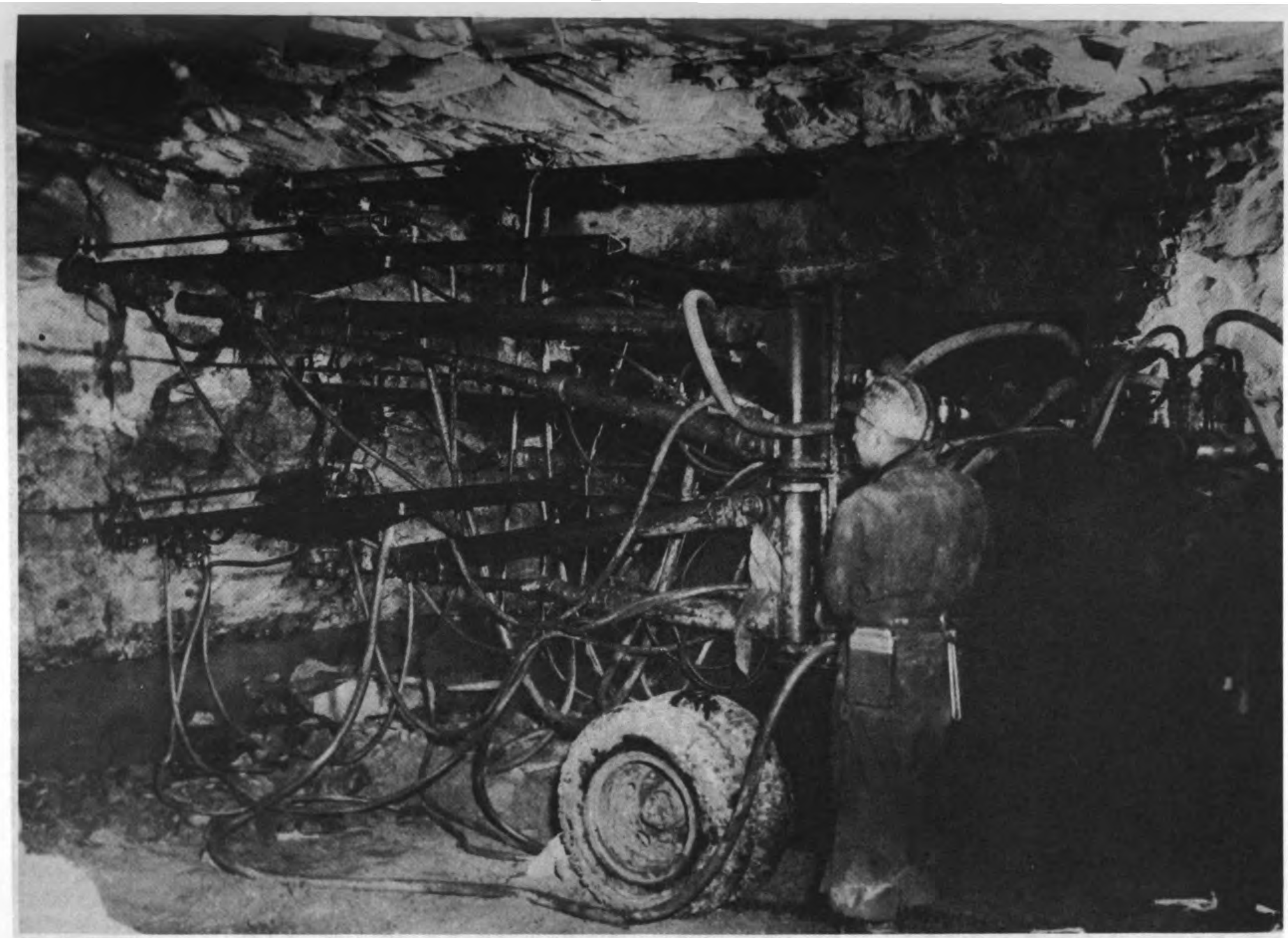


Figure 9. - Drilling blast-hole round in ore that averages about 15 feet in thickness with 4-drill jumbo.

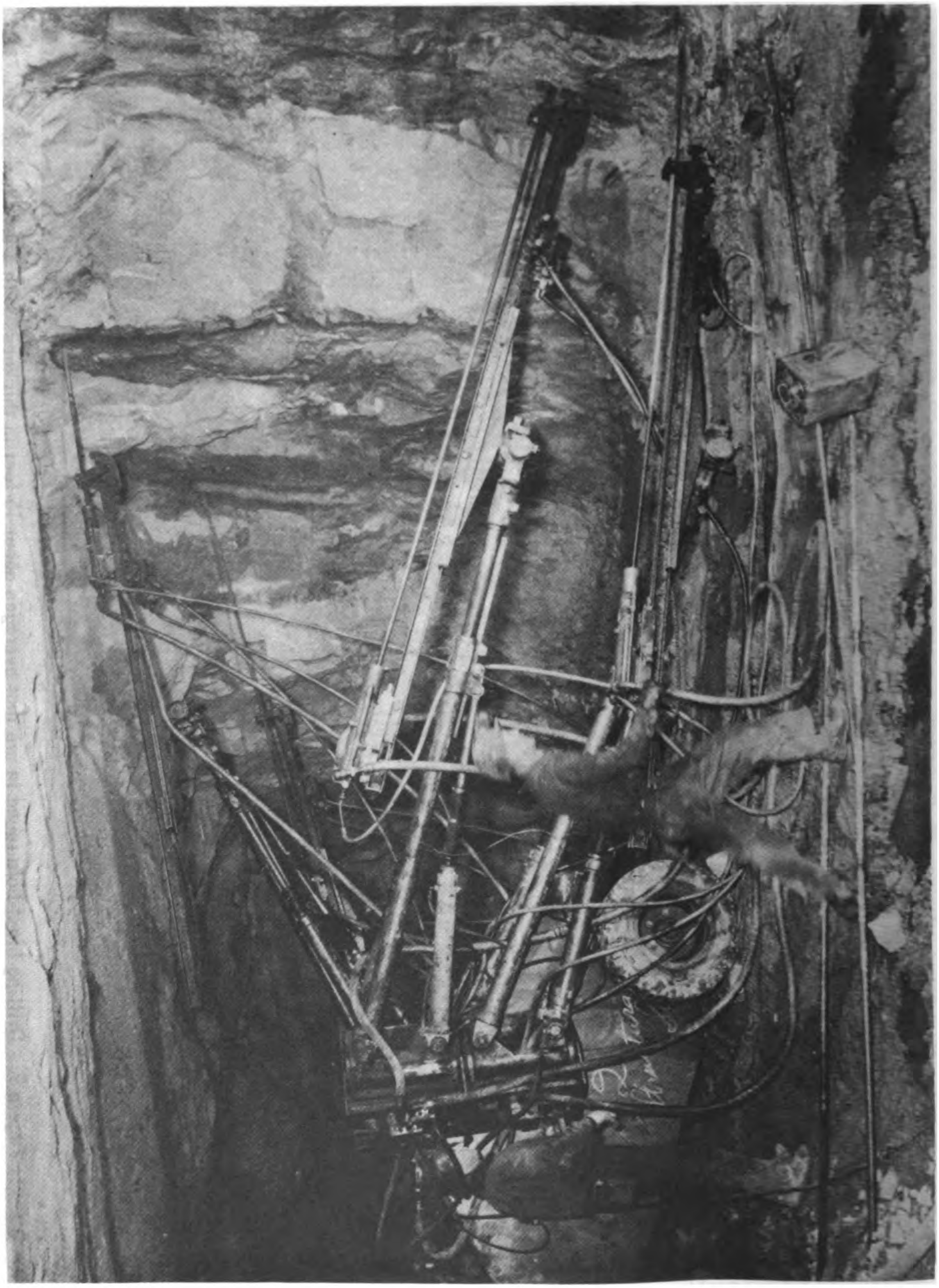


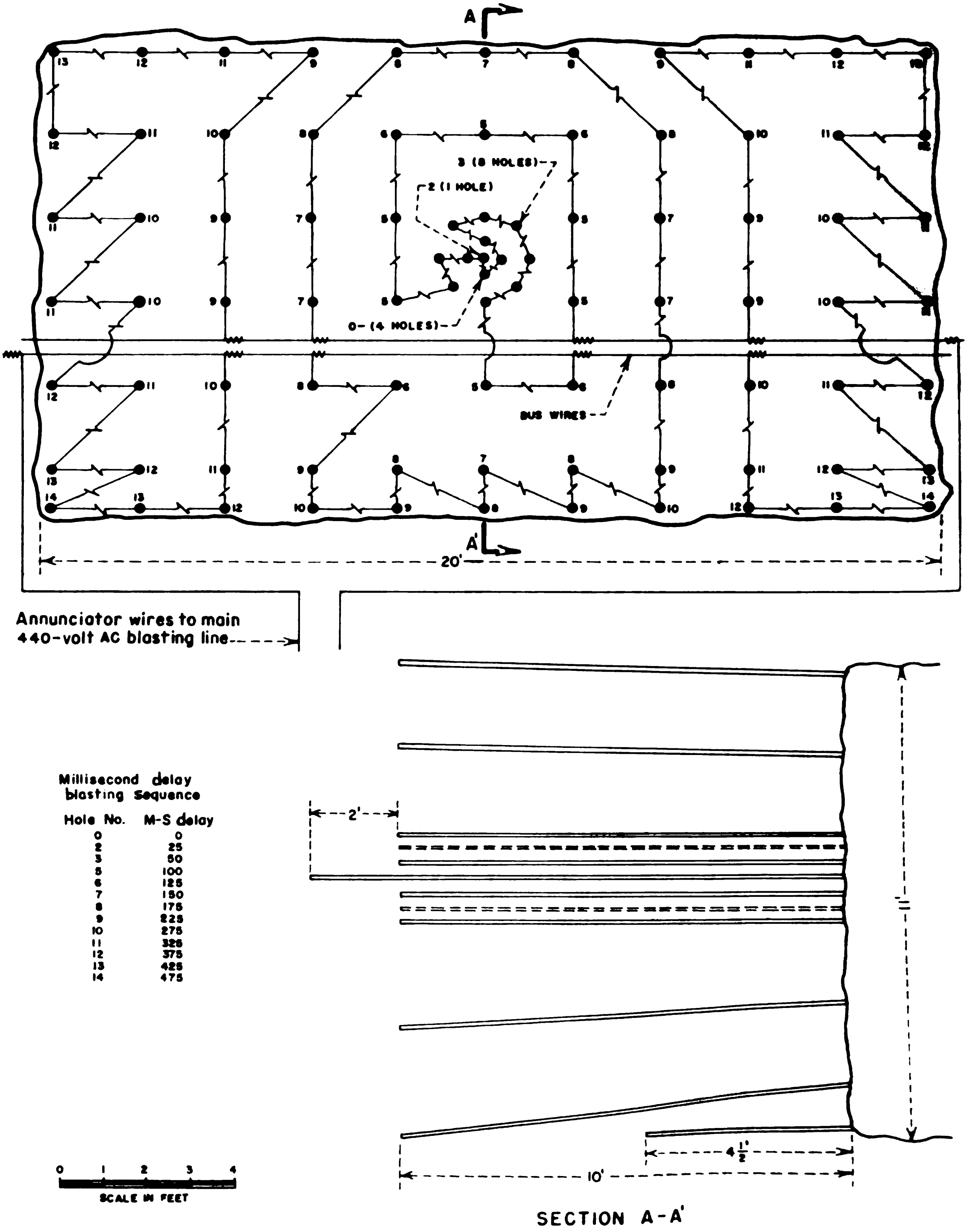
Figure 10. - Drilling a round in ore 10 feet thick with the 4-drill jumbo.

pump is in continual operation while drilling and maintains pressure in the hydraulic system. The extensible booms are 9 feet long but can be extended to 12 feet manually by turning a pinion gear on the main boom section that lengthens the telescoping extension section. The extensible booms are positioned vertically and horizontally by two hydraulic-actuating cylinders that hinge from the same mounting base on the jumbo frame, extending out and attached to pivot near the end of main boom section. The lift cylinder is mounted beneath the extensible boom and can pivot the boom vertically through a 100° arc. The swing cylinder is mounted on the side of the extensible boom and can pivot the boom horizontally through a 100° arc. The drill shells are mounted on short crossbars, off center with the extensible booms, permitting the drill shells to swing down to a near horizontal position to drill bottom holes. Two 3-1/2-inch rock drills are mounted on the bottom booms, and two 3-inch drills are mounted on the top booms. The shells have drill-steel stabilizers to lessen drill-steel vibration. Twelve-foot, 1-1/8-inch round drill steel with 1-5/8-inch diameter detachable tungsten carbide bits are used. The 12-foot shells and drill steel permit drilling the 10-foot blast holes without steel changes. Principal steel breakage occurs at the lugged ends but with the extra length of the steel, 2 or 3 additional shanks can be reforged. Bit life approximates 1,500 feet.

Two men operate the four drills by a system of remote-control valves mounted together on each side of the drill jumbo frame. Each operator controls the movement of the 2 extensible booms and the 2 rock drills on his side; each complete drill assembly is controlled by 5 valves. To position the boom, one two-way hydraulic valve can move the lift cylinder up and down and a similar valve can move the swing cylinder left and right. Drill feed is controlled by a two-way compressed-air valve, moving the drill forward and backward on the shell. The other two valves control air and water for drill operation. There are no controls to change the horizontal or vertical inclination of the shell relative to the boom. When the boom is repositioned to drill another hole the drill shell assumes a slight variation in direction. The bolts on the saddle clamp and shell mount are tightened enough to permit the shells to be quickly and correctly aligned by butting the centralizer or drill bit to the face and changing the direction of the shell by movement of the actuating cylinders. Air is supplied to the jumbo from the main air line by a 2-inch-diameter hose. Water is supplied through a 1-inch hose.

When a round has been drilled, the jumbo is quickly moved by the Eimco tractor and positioned at the next face to be drilled. The tractor is then free to be recoupled to the Gismo for mucking service. Except for the few minutes required twice each shift to move the drill jumbo, the tractor works full time with the loading unit. The need of a second tractor is therefore eliminated.

Drill holes, except for the cut and reliever holes, are spaced roughly on 2-foot centers. A drill round in 9- to 11-foot ore usually consists of 88 holes, the number increasing as the height of the ore increases. If during drilling, enough change is noted in the toughness and hardness of the ore, hole spacing is modified at the discretion of the shift boss or drillers. A 5-hole burn cut surrounded by 8 reliever holes drilled on about a 2-foot-diameter circle is used. All holes, except the center cut hole and the bottom or secondary row of lifter holes, are drilled 10 feet deep. The center cut hole is drilled about 2 feet deeper. The secondary row of lifter holes consists of shorter holes drilled just 4-1/2 feet deep to break the hump left near the collars by the main lifter holes and assure a smooth haulage bottom. A typical drift round for ore 9 to 11 feet high is shown in figure 11.



Annunciator wires to main 440-volt AC blasting line

Millisecond delay blasting Sequence

Hole No.	M-S delay
0	0
2	25
3	50
5	100
6	125
7	150
8	175
9	225
10	275
11	325
12	375
13	425
14	475

Figure 11. - 88-hole round with 5-hole burn cut in 11-foot ore. Millisecond-delay electric blasting caps wired in parallel-series circuit, Big Buck mine, San Juan County, Utah.

When advancing in 12-foot ore, it takes slightly less than 4 hours to move the drill jumbo into position, complete the setup, and drill the 99-hole round. Average rate of drilling, including setup time, is about 115 feet per man-hour for 2 drills.

In blasting, medium-velocity 40-percent dynamite is used in cartridges 1-1/8 by 24 inches. Primer cartridges are 1-1/8 by 8 inches. The company first used dynamite in 8-inch cartridges but to reduce loading time experimented with 16-inch cartridges and later with 24-inch cartridges. It was learned that adequate compaction was possible using the longer cartridges, and their use would cut loading time by about one-third. All holes except the cut holes are loaded to within 2-1/2 to 3 feet from the collar. Primer cartridges are placed at the bottom of the holes. Stemming is not used. The center hole of the burn cut, which is drilled about 2 feet deeper, is loaded with only 1 or 2 8-inch sticks of dynamite, which are detonated immediately after the other 4 cut holes to clear the cut. The management favors millisecond-delay blasting, which produces better fragmentation, thereby speeding the loading time of the Gismo and eliminating some lost time of the tramming crew, which would result from chute hangups caused by large material and the need of secondary blasting. Also, the ore-buying station at Moab stipulates that the delivered ore must be minus-12-inch size. The high holes in a round are loaded from a Caterpillar HT-4 front-end-type loader (see fig. 12). The company has just completed building a flatbed platform that, bolted to the bucket on the loader, provides a larger platform from which to work.

After a round has been loaded, 2 dry wooden stakes are wedged into two of the drill holes, 1 on each side of the face. These stakes extend about 2 feet outward from the collars of the holes and are placed so as not to reach the powder in the hole nor damage the primer lead wires. Two separate lengths of 16-gage uninsulated copper bus wire are strung parallel across the face and secured to the stakes with the inside wire free of the face and with about 12 inches between the two. The blasting cap lead wires are then connected in series groups, a maximum of 25 primers in a series. The lead wires from the primers at the ends of each series are connected in parallel to the bus wires. Sixteen-gage annunciator wires connect the bus wires to the main service blasting line to complete the circuit (fig. 11). Each series group is tested with a blasting galvenometer before it is connected to the bus wires. The entire blasting circuit is tested before contact is made with the power source.

The main service blasting lines are 8-gage insulated copper wires upon which is imposed a 440-volt alternating current to detonate a round. These main lines are securely mounted on insulators placed along the back of the workings away from other powerlines and maintained to within about 100 feet of the working faces.

The blasting station is in the adit at its intersection with the incline. The blasting switch is a double-pole, single-throw type near the underground transformer station. The 440-volt mine powerlines from the transformer station are permanently connected to the switch box. A temporary connection is made between the switch box and the blasting lines by flexible jump cords, which are strung across the adit immediately before blasting. The blasting switch is kept locked in an off position at all times except to detonate a blast. Blasting is done only at the end of the night shift, about 12:45 a.m.

Loading and Transporting

The Gismo loader unit is very simple in function, design, and construction. A single pin couples the front end of the Eimco diesel tractor to the rear end of the

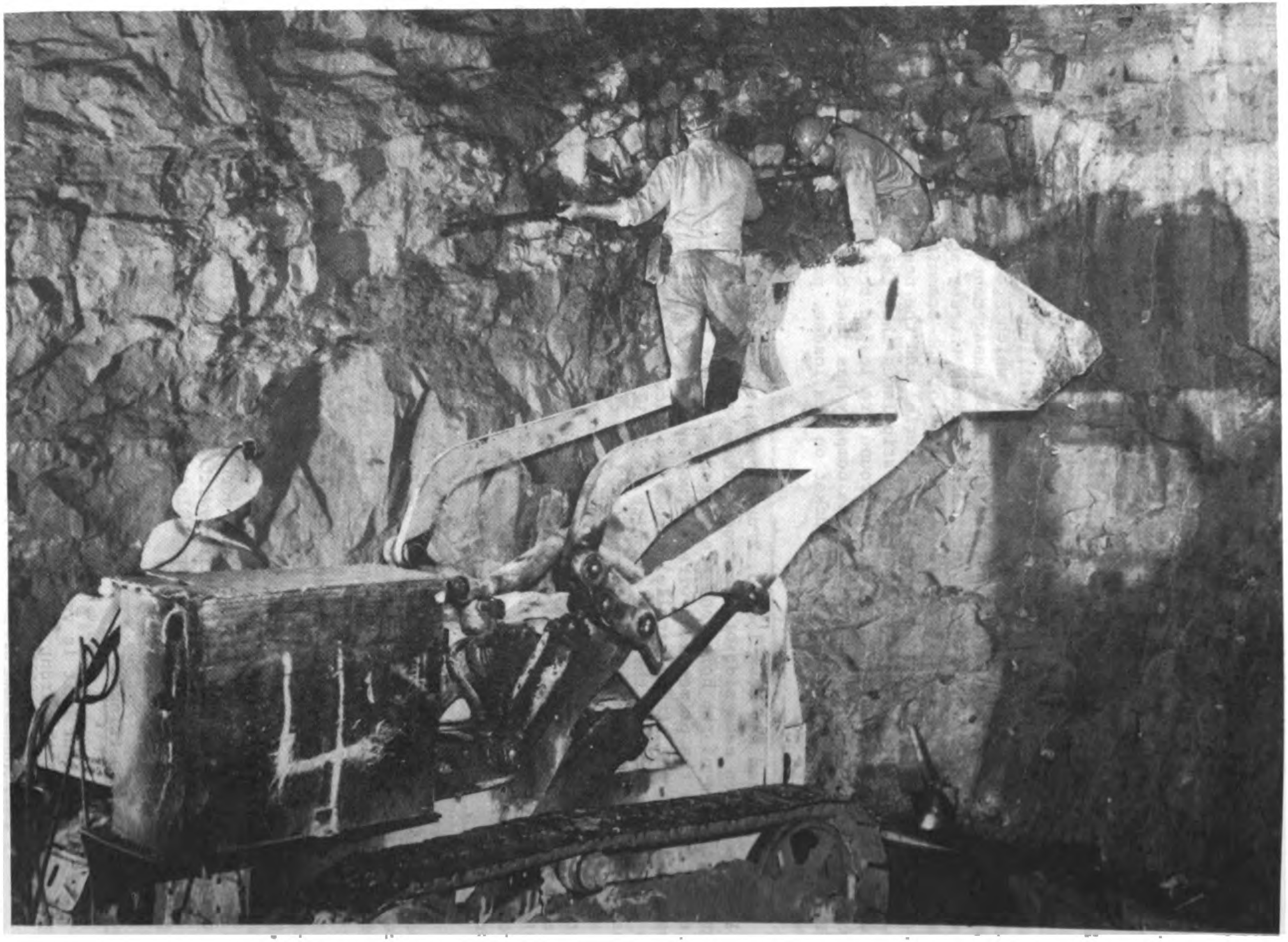


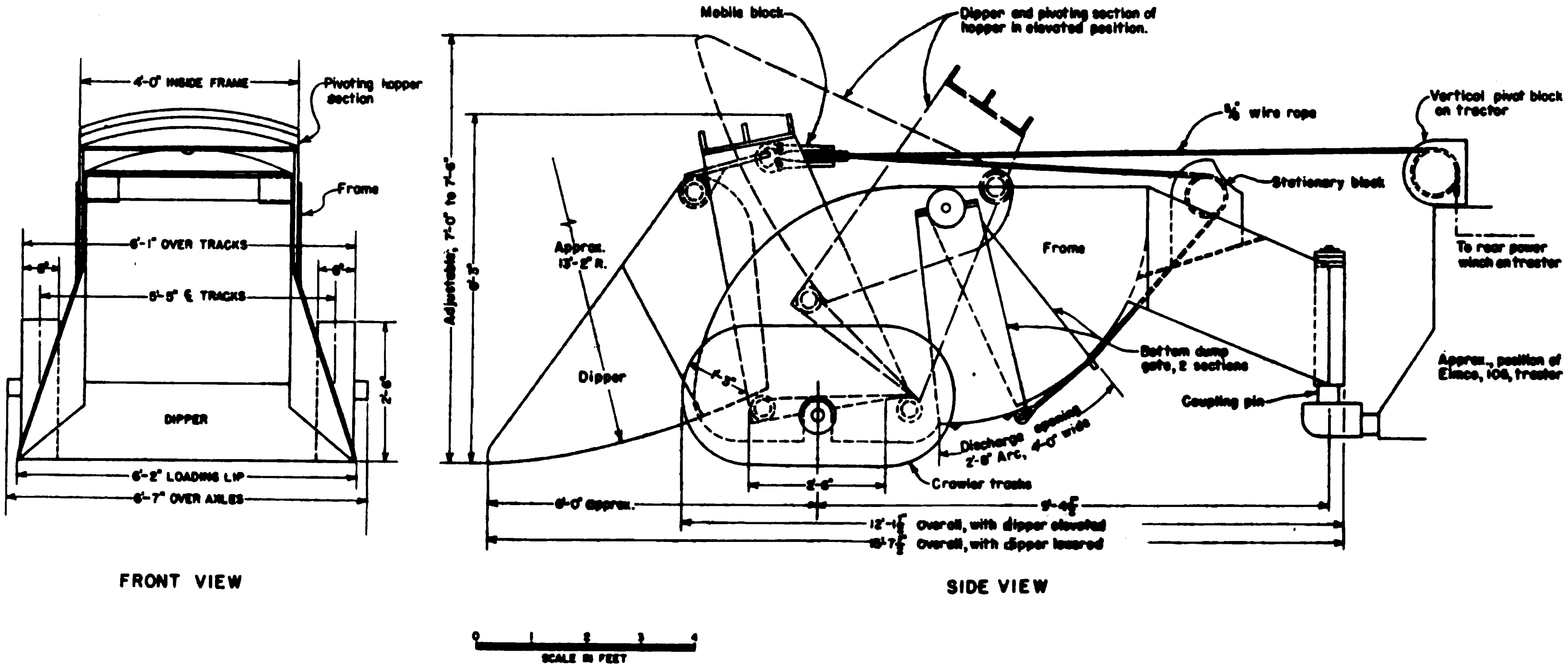
Figure 12. - Three-man powder crew loading upper holes in drill round, using front-end-type loader.

loader. Together, these become a rugged self-contained machine for loading, transporting, and dumping ore. The entire unit is operated by one man who does not have to leave the cab of the tractor. The Gismo is 6 feet, 7 inches wide and with the dipper lowered is 15 feet, 7-1/2 inches long and 6 feet, 3 inches high. With the dipper raised to its maximum height, the Gismo is 12 feet, 1-1/2 inches long and 7 feet, 6 inches high. Coupled to the Eimco tractor the two units are 30 feet, 8 inches in length. Minimum operating height required is 7.5 feet. The loader unit is mounted on crawler tracks that permit low construction of the hopper with ruggedness and stability when loading and transporting (see fig. 13).

The hopper and dipper are designed to hold about 6 tons. The dipper and the forward section of the hopper comprise the forward one-half of the Gismo. Actuated by a 5/8-inch wire rope from the rear winch unit on the tractor, both pivot upward about a horizontal axis, the dipper pivoting within the forward part of the hopper. The dump gate, at the bottom and rear of the loader, is in two sections, which are opened upward by the same wire rope which actuates the two forward sections. From a vertical block mounted off center on the front of the tractor, the wire rope runs forward through a single mobile block on the dipper, back through a vertical stationary pulley mounted on the rear of the hopper frame, and then down and is secured to the bottom-most section of the dump gate. When loading and transporting ore, the bottom-dump gate is kept locked by a trip mechanism operated from the cab of the tractor, so that when applying intake power to the rope, only the dipper is actuated.

The bottom of the dipper is constructed with a slight downward curve to assist its scooping loading action. The dipper blade is 6 feet, 2 inches wide with hard metal facing inserts along the lip. The hopper is constructed low, about 8 inches above the stope bottom. The low construction of the dipper and hopper minimize the height that the ore must gain when crowded from the ore pile to a place on the dipper.

When approaching a newly broken round, the Gismo cleans up the scattered fly rock in the same manner as when loading from a pile and therefore acts as its own road maintainer. The loading action is caused by lowering the dipper to the floor and crowding it into the muck pile, using the bottom of the stope as a guide much like shoveling by hand. As the dipper is crowded into the ore at the base of the pile, the forward motion of the loader is slowed. The operator then lifts the dipper slightly and the dipper continues its crowding action at a height a little above the base of the ore. The operator continues to crowd the ore raising the dipper gradually to assist the biting action of the dipper. In practice, the manner of loading the dipper resembles an upward scooping action. As the Gismo moves forward and upward, its crawler tracks mount the feather edge of the ore pile and the whole unit assumes a slight inclination. When the dipper is full and while the loader is still in its most forward position, the operator lifts the dipper forcing the ore back into the hopper (see fig. 14). Because of the inclination of the loader and the upward slicing action of the dipper, the ore is assisted onto the dipper by gravity. The inclination of the loader also enables the dipper to more easily force the ore back into the hopper. The operator repeats the procedure until the hopper is full, beginning each time by crowding the base of the ore pile. After the hopper is full, the operator takes one additional pass to fill the dipper, raising it enough to prevent spillage in transport. The number of passes necessary to fill the hopper will vary according to conditions, but the operator can load the hopper in as few as four. Tonnage per trip will average 4 to 6 tons. The Gismo can adequately clean up the bottom at a face to exclude the need of any special equipment or hand work.


4'-0" INSIDE FRAME
Pivoting hopper section
Frame
6'-1" OVER TRACKS
6"
6"
5'-5" ℄ TRACKS
2'-6"
DIPPER
6'-2" LOADING LIP
6'-7" OVER AXLES
FRONT VIEW
Mobile block
Dipper and pivoting section of hopper in elevated position.
5/8" wire rope
Vertical pivot block on tractor
Stationary block
To rear power winch on tractor
Adjustable; 7'-0" to 7'-6"
6'-3"
Approx. 13'-2" R.
Frame
Dipper
Bottom dump gate, 2 sections
Approx., position of Eimco, 108, tractor
Coupling pin
Discharge opening 2'-8" Arc, 4'-0" wide
Crawler tracks
2'-6"
6'-0" approx.
9'-4
12'-1 Overall, with dipper elevated
13'-7 Overall, with dipper lowered
SIDE VIEW
0
1
2
3
4
SCALE IN FEET

Data obtained from Stanford-Day Iron Works Inc., Knoxville, Tenn.

Figure 13. - Outline dimensional drawing of Gismo, model 46, showing lowered and elevated positions of loading dipper, Big Buck mine, San Juan County, Utah.

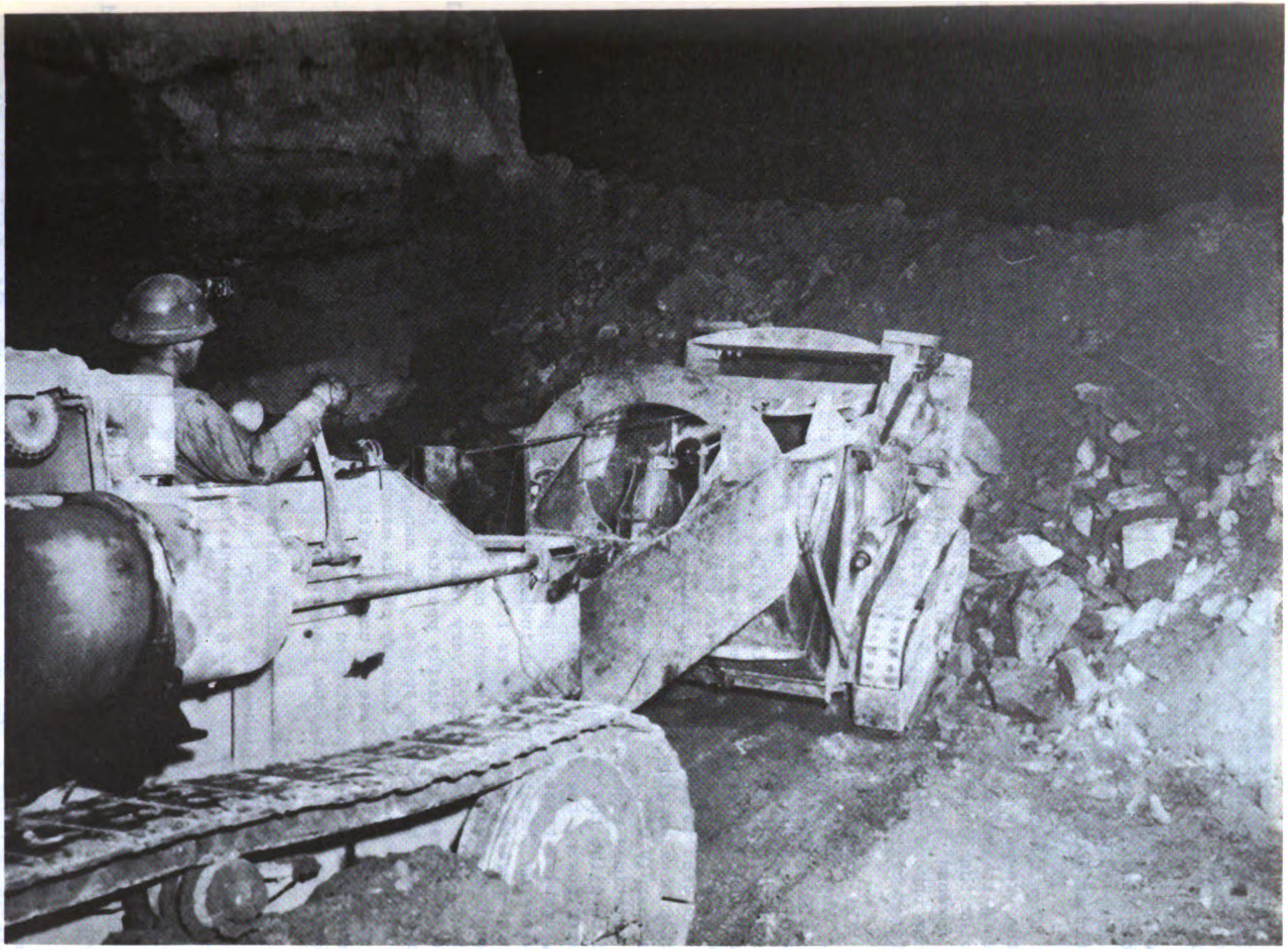


Figure 14. - Loading model 46 Gismo.

Because of the slowness of travel, the Gismo is limited to relatively short hauls; the distance between ore passes was planned accordingly. Maximum haulage distance desired is about 300 feet, although it is realized that conditions will arise where transport distance will equal 350 or possibly 400 feet. When hauling 300 feet, the complete loading and haulage cycle is about 6 minutes, or very near 1 ton per minute. The ore passes are located so that the tractor can arrive and leave from either direction with minimum time getting into dumping position. The ore passes are 3 by 5 feet at their collars; the collar of the center ore pass being constructed of timber and the others of steel and concrete.

When dumping, the operator pulls the loader unit to straddle the long dimension of the ore-pass collar. Releasing the dump-gate trip lock by the hand cable that extends to the cab of the tractor, the operator applies power to the actuating cable forcing the dipper tight against the ore in the hopper. The cable is pulled through the forward block opening the bottom section of the dump gate. The bottom section slides upward opening the upper section. The ore then slides through the dump gate assisted by the crowding action of the upward pivoting dipper (see fig. 15).

The tractor operator requires no exceptional skill when transporting or dumping ore. The Gismo loader is easily pulled behind the tractor. Loading the Gismo is more difficult and requires skillful handling of the tractor. The loader must be pushed ahead of the tractor, positioning it much in the same manner as when backing a semitrailer. The single-pin coupling system between the tractor and loader requires that the tractor be centered directly behind the loader when crowding the muck pile. Originally, a crawler tractor with friction-clutch control of the crawlers was used to motivate the loader. This tractor lacked enough power to load quickly when working on an upgrade and was awkward to handle in limited space. To turn sharply within a limited space and correctly approach an ore pile, the operator was sometimes required to back the tractor from his original turn and then go forward to aline the two units. To decrease the loading time and satisfy the need for greater power, the company, in November 1955, put into operation the Eimco, model 105, crawler tractor, which is powered by a 125-hp. Cummings diesel engine. The crawlers on this tractor have individual torque-converter drives. Separate forward-neutral-reverse control levers for each crawler permit individual control either in forward or reverse. By throwing one crawler in forward and the other in reverse the tractor can be made to turn very sharply. Crawler brakes are used when making normal turns in transport. An easily operated speed-range lever permits travel in either direction at high or low speeds. The management favors the Eimco, model 105 tractor for its Gismo operation because of its maneuverability when positioning and loading the Gismo loader, its ease of control with less fatigue to the operator, and its greater power. The operator on this tractor sits well forward, permitting good vision when positioning the loader.

The Gismo is used to advantage where blending is desired. Low-grade material can be blended with high-grade ore by hauling alternate loads from two or more headings. At least eight operating headings are considered necessary to keep the equipment at maximum operating capacity. These consist of 3 headings ready for drilling and blasting, 3 containing broken ore for loading and transporting, and 2 open for scaling and roof bolting.

The collars of the ore passes must be left open. Three heavy chains are secured across the ore-pass collars to provide a safety precaution for personnel (see fig. 16). Adequate spacing between the chains and sufficient slack enables the ore to easily fall past them. When an ore pass is not used for any period of time, a steel frame with heavy wire mesh is placed over its collar. Sealed-beam-type electric lights are pointed at the ore-pass collars so that no one will fail to see them.

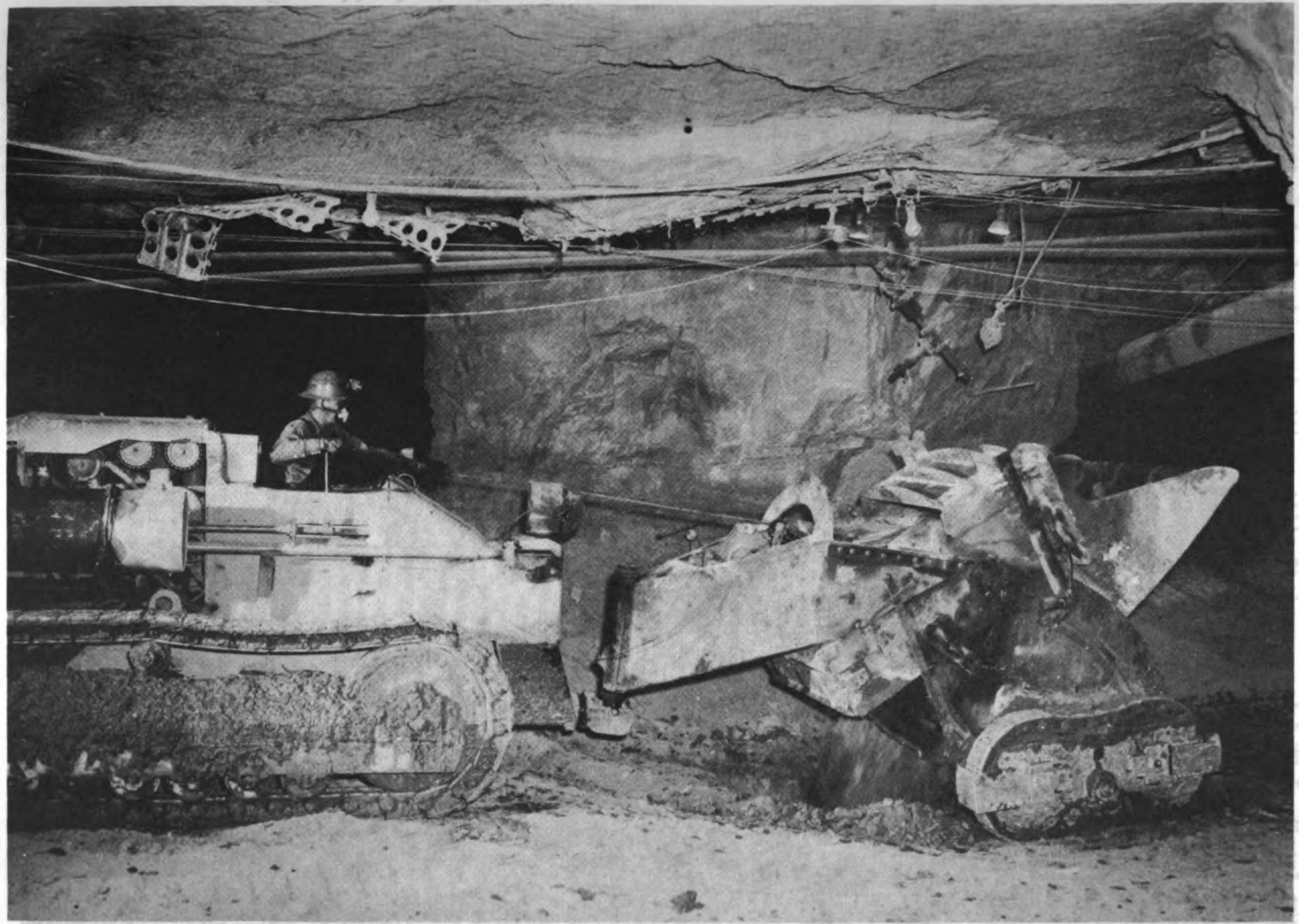


Figure 15. - Dumping ore from Gismo into ore pass.

Original from THE OHIO STATE UNIVERSITY

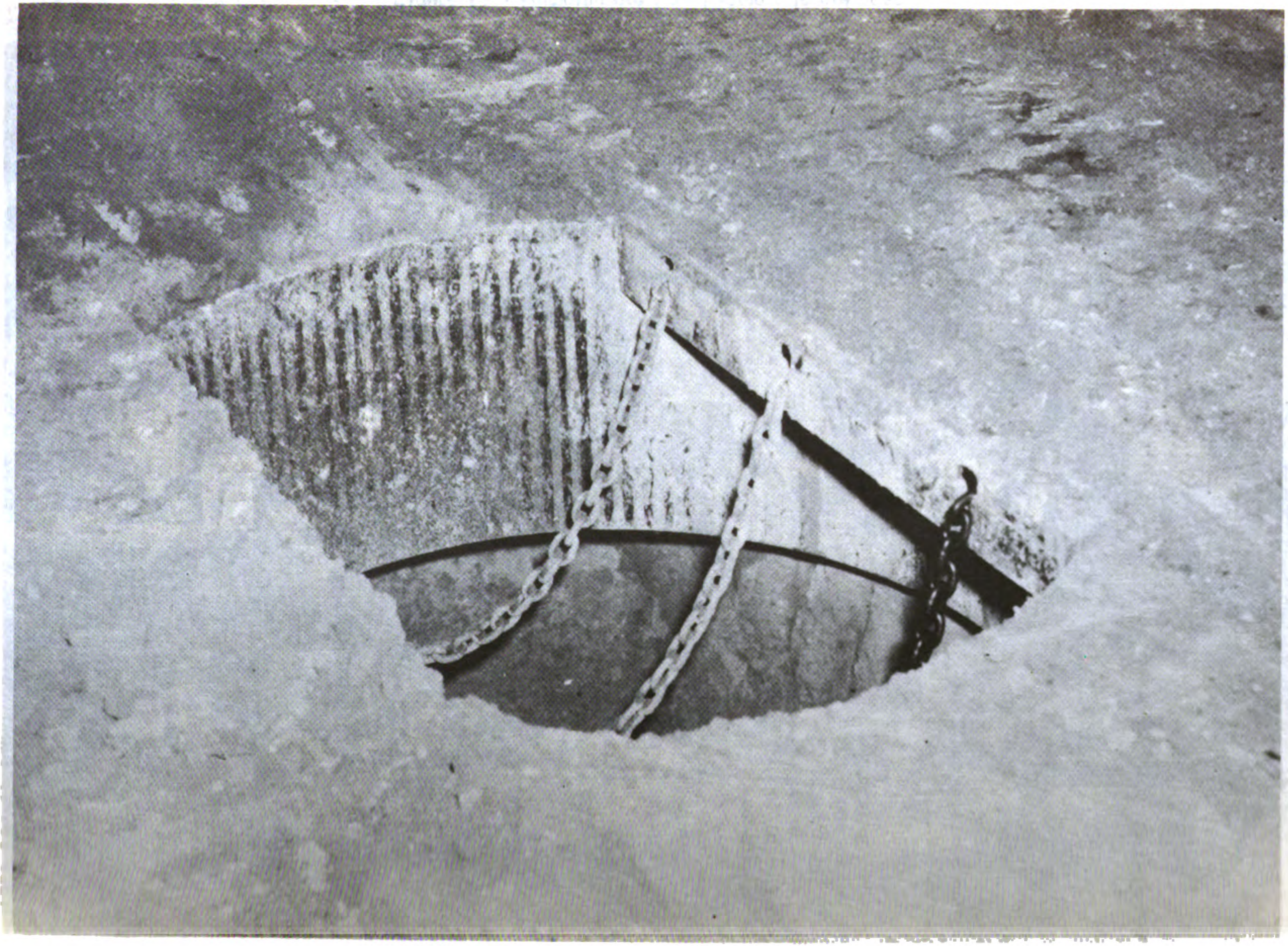


Figure 16. - Steel collar and safety chains of north ore pass on stope level.

Another Gismo loader is used with an Allis-Chalmers, model HD-5, diesel tractor for driving the southeast heading on the stope level. This unit is a standby and is transferred to production when either the Eimco tractor or the other Gismo require repairs.

Two men on each shift are advancing the southeast heading on the stope level for connection with the workings of the North American shaft, which will assist greatly in ventilating the mine. The miners use air-leg-type drills for drilling blast-hole rounds in this heading.

Where the ore thins below the minimum operating height of the drill jumbo and the loader units along the southwest limit of the ore body, the company plans to use air-leg-type pneumatic rock drills to drill the ore and scrapers to transport the ore to points where the Gismo can load it efficiently.

Transportation on Haulage Level

Track haulage is used to transport ore on the adit haulage level. Gismo haulage on the stope level was described under the section on mining.

The mine locomotive is a 6-ton Mancha powered by a 67-hp. GMC diesel engine. C. S. Card Iron Works Co., 60-cubic-foot-capacity Granby-type mine cars are used. Mine rail size is 45 pounds per yard and is laid to 24-inch gage. Rail ties are native timber, 6- by 6-inch, spaced on 3-foot centers. The ties are well ballasted, and the track is maintained in good condition. The grade of the mine track is 0.5 percent. Refuge stations are 200 to 300 feet apart along the haulage level for safety of personnel from passing trains.

A haulage trip consists of 7 mine cars, and the average trip cycle requires 20 minutes. Present maximum ore-haulage distance is about 2,380 feet. Although the locations of the two ore passes to the southeast are as yet tentative, maximum ore-haulage distance may be 3,000 feet. The tramming crew on each shift consists of a motorman and helper.

The underground ore chutes are constructed of 8- by 8- and 8- by 6-inch fir timbers. The chute lips are 36 inches wide, inclined at 50°. Steel-arc, underswung chute gates, operated by 6-inch-diameter, 28-inch stroke pneumatic-air cylinders permit fast and efficient mine-car loading. Figure 17 shows ore-chute and arc-gate design on the adit haulage level. Advantage of the underswung gate, which is closed by lifting through the ore, are its adaptability to coarse ore and ease of control with less tendency to jam. The motorman's helper operates each chute gate by a two-way compressed-air valve at a station on the haulage level opposite the ore chute (see fig. 18). The helper assists the motorman in positioning the mine cars by flashing a signal light mounted at the back of the adit. It takes 2 to 3 minutes to load the 7 mine cars.

An Army surplus, four-wheel-drive, rubber-tired scout car powered by a Buda diesel engine has been cut down and is used to transport men, small equipment, powder, fuel oil, and other supplies from the surface to the working places. Since the time the interconnection was made with the Mi Vida workings, men, supplies, and equipment are transported to the Big Buck stope level through the easternmost Mi Vida surface incline rather than through the Big Buck adit and incline.

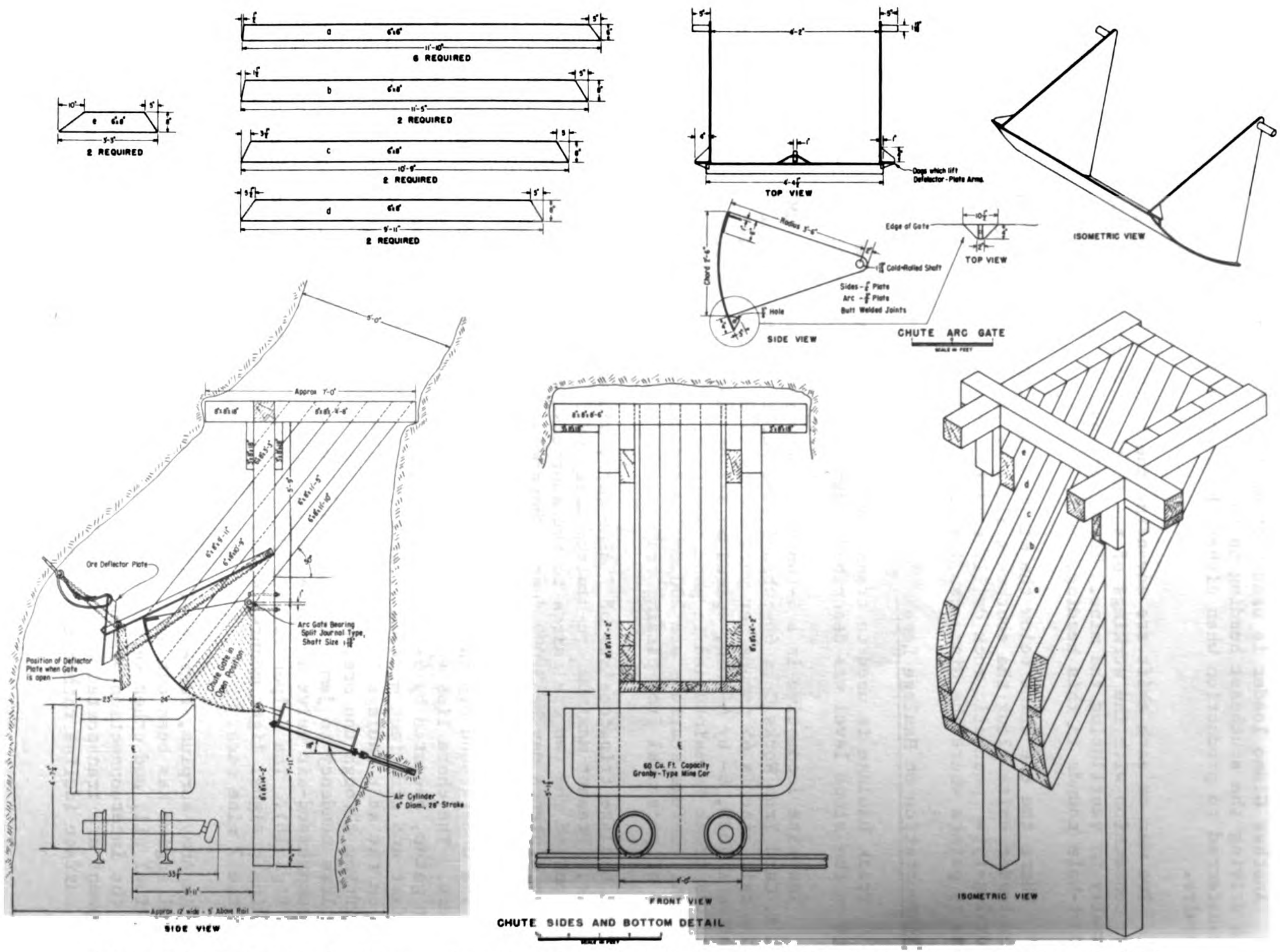

a 6"x8" 11'-10" 6 REQUIRED
b 6"x8" 11'-5" 2 REQUIRED
c 6"x8" 10'-9" 2 REQUIRED
d 6"x8" 9'-11" 2 REQUIRED
e 6"x8" 3'-3" 2 REQUIRED
4'-2"
4'-4"
TOP VIEW
Dogs which lift Deflector-Plate Arms.
Radius 3'-6"
Chord 2'-6"
1 1/2" Cold-Rolled Shaft
Sides - 1/2" Plate
Arc - 3/8" Plate
Butt Welded Joints
Hole
SIDE VIEW
Edge of Gate
TOP VIEW
CHUTE ARC GATE
SCALE IN FEET
ISOMETRIC VIEW
5'-0"
Approx. 7'-0"
Ore Deflector Plate
Position of Deflector Plate when Gate is open
Arc Gate Bearing Split Journal Type, Shaft Size 1 1/2"
Chute Gate in Open Position
Air Cylinder 6" Diam., 28" Stroke
23"
24"
33"
Approx. 12' wide - 5' Above Rail
SIDE VIEW
60 Cu. Ft. Capacity Granby-Type Mine Car
FRONT VIEW
CHUTE SIDES AND BOTTOM DETAIL
SCALE IN FEET
ISOMETRIC VIEW

Figure 17. - Underground ore-chute and arc-gate design, adit haulage level, Big Buck mine, San Juan County, Utah.

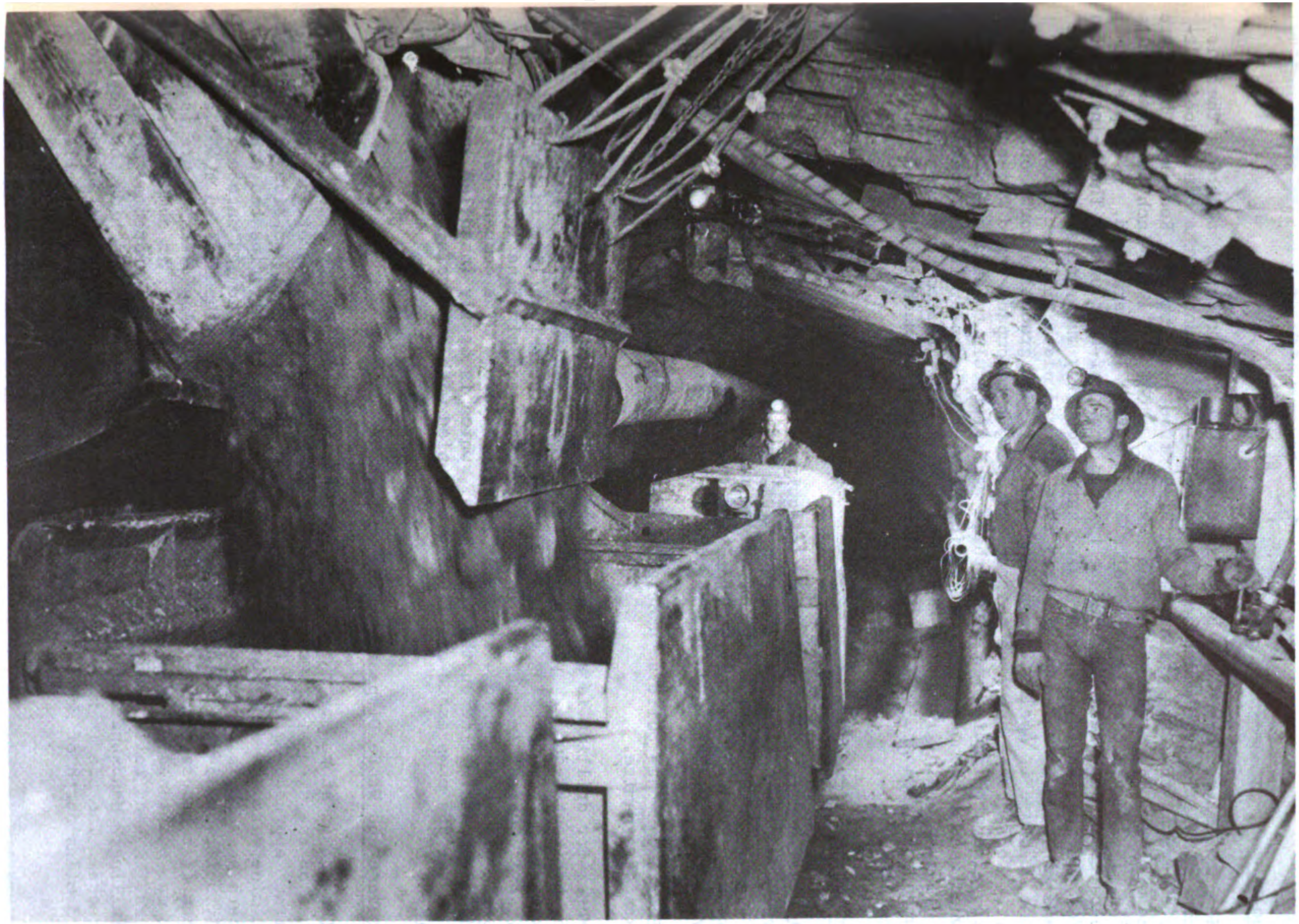


Figure 18. - Loading 60-cubic-foot-capacity, Granby-type mine car at ore-pass station on haulage level. Underswung arc gate is operated by a compressed-air cylinder controlled by motorman helper on right.

Auxiliary Operations

Roof Bolting

No particular trouble has been experienced with rock falls, although there is intermittent spalling of mudstone lying directly above much of the ore. Roof bolting is done from the Caterpillar, model HT-4, front-end loader. Roof-bolt holes are drilled with a stoper, using 7/8-inch hexagonal steel and 1-1/8-inch detachable bits (see fig. 19). One-inch-diameter bolts 4 and 6 feet long are used. A compressed-air-operated impact wrench is used to tighten the roof-bolt nuts. Three-inch wooden and 1/4-inch steel-head plates are used satisfactorily when areas where the back is hard and blocky are roof-bolted. This type of head plate will not hold the softer mudstone, because it spalls from around the plate and gradually works out from behind it. To increase the area covered per bolt, the company tried war-surplus, punched, aircraft landing mats, but these were difficult to handle and were expensive when used to completely cover a wide area. The company is now considering bolting heavy, chain-link, wire mesh, which will give greater coverage with a minimum number of bolts and will, it is believed, eliminate much of the roof-bolt maintenance.

Underground Repair Shop

A small underground repair shop is equipped with general small shop tools, electric and oxyacetylene welding equipment, and spare parts to make rock-drill repairs and minor repairs on the trackless mining equipment (see fig. 20). Here all equipment is greased and serviced daily by the night serviceman. One- or two-days' supply of fuel oil is stored underground in sealed drums.

The company has built an underground explosive magazine to store a maximum of 50 boxes of dynamite.

Water for drilling is supplied through a 2-inch main line by a compressed-air-driven, horizontal-duplex, piston pump on the main haulage level. To prevent the main waterline from freezing during cold weather, the 2-inch line is insulated for the first 1,600 feet in the adit. The main compressed-air line in the adit is 6-inch steel pipe reduced to 4 inches at the stope level. The company has begun using aluminum 4-inch air line on the stope level, which is easily installed and taken down. Water and compressed-air lines are coupled with commercial split-ring-type couplings.

Ore Storage and Waste Disposal at the Surface

The ore is stored at the surface in three 100-ton-capacity steel ore bins constructed on the side of the canyon about 8 feet below the level of the mine yard. Mine-track approach is on a trestle built from the sloping canyon side to the height of the mine yard. A camel-back-type dump trip automatically tips the Granby-type mine cars as each is centered above the bins. The ore is dumped onto a 12-inch grizzly built of 45-pound mine rail that extends down to the bins on a 45° angle and then flat across the top of the bins (see fig. 21). Any oversize ore is broken by the man stationed at the grizzly. Because the ore is dry, it dumps cleanly from the cars. A hand rail welded to the outer sides of the bins protects the grizzlyman from falling. Hand-operated gates are used at the bottom of the bins for loading ore trucks. The ore is hauled 45 miles by contract truckers to the buying station about 3 miles north of Moab. Contract haulage cost is $0.06 per ton-mile.

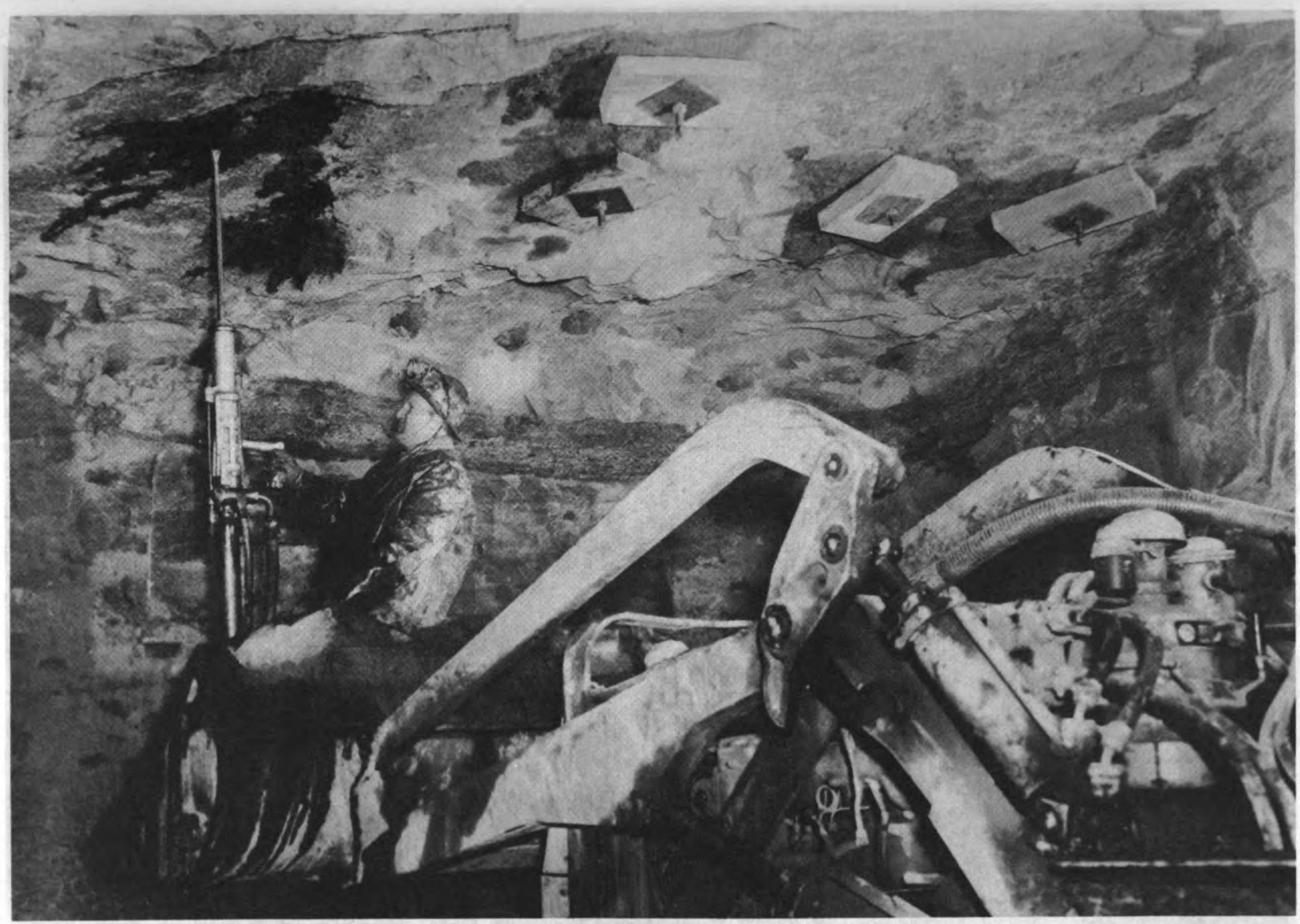


Figure 19. - Collaring drill hole to install a roof bolt.

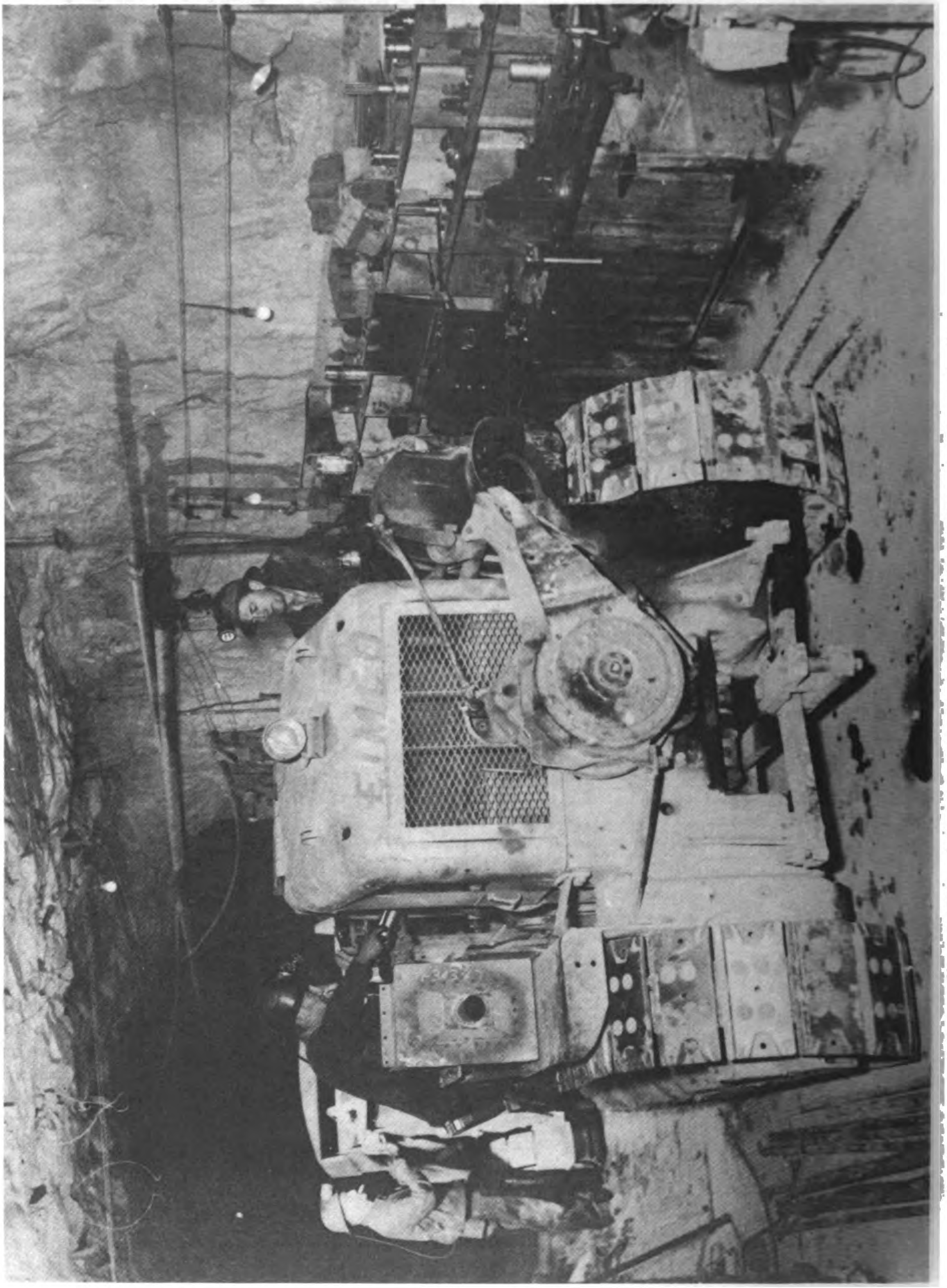


Figure 20. - Servicing Gismo and tractor at underground repair shop.

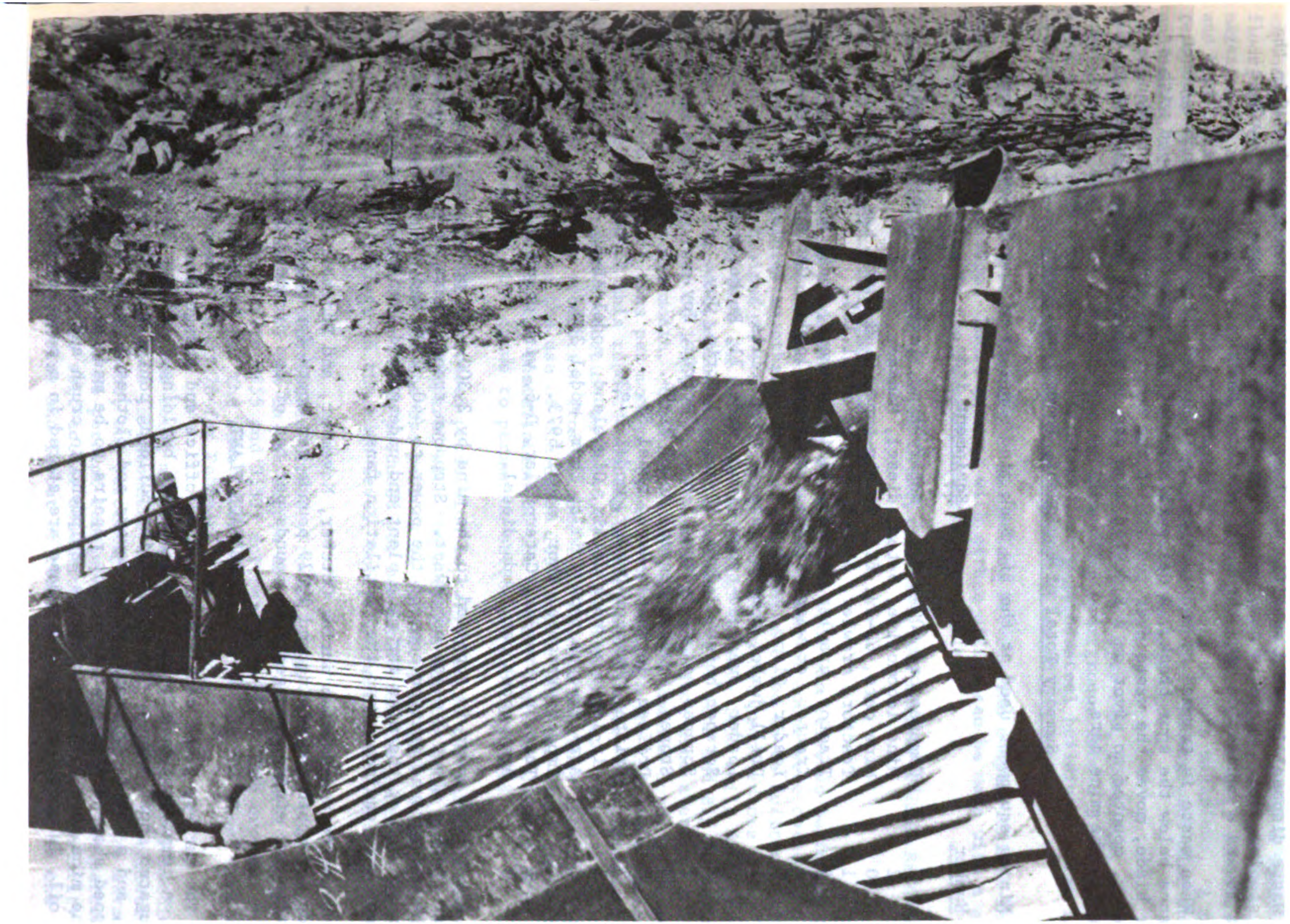


Figure 21. - 60-cubic foot capacity, Granby-type mine car dumping ore onto the 12-inch grizzly at the surface ore bins.

Waste disposal is not a specific problem, for little is encountered within the main stoping area. Waste is now coming from driving the southeast adit haulage drift toward a connection with the North American shaft.

When waste is trammed to the surface, it is dumped onto a waste bench a short distance below the spur track. A Caterpillar, model D-6 tractor, equipped with a dozer blade, moves the waste over the rim of the dump. An air-operated hydraulic cylinder, mounted to pivot on a flat-bed mine car on parallel tracks, is used to tip and empty the mine cars.

Summary Total of Equipment, Power, and Powder

Mining equipment used at the Big Buck mine consists of the following items:

Number	Equipment item
2	Compressor, 600-c.f.m., rotary-type, Ingersoll-Rand, Gyro-Flo.
2	Mine locomotive, 6-ton, diesel, Mancha.
10	Mine cars, 60-cu. ft., Granby-type, C. S. Card.
1	Tractor, crawler, diesel, Eimco, model 105.
1	Tractor, crawler, diesel, Allis-Chalmers, model HD-5.
1	Tractor, crawler, diesel, front-end loader, Caterpillar, HT-4.
2	Loader, Gismo, model 46.
1	Drill jumbo, company-made, 4 rock drills.
1	Loader, overhead-type, Eimco, model 21, Rockershovel.
2	Scraper hoist, 3-drum, 10-hp., electric, Joy.
1	Scraper hoist, 2-drum, 5-hp., electric, Joy.
2	Stoper, Gardner-Denver, model RL-94.
2	Drifter, Ingersoll-Rand, model 35.
2	Drifter, Gardner-Denver, model D-93.
3	Air-leg-type rock drills, Cleveland, model AL-92.
2	Air-leg-type rock drills, Thor, model 380.
2	Impact wrenches, Thor, model 6973.
1	Tractor, crawler, Caterpillar, D-6, with dozer blade.
1	Army scout car, Buda diesel.

Electrical power is supplied to the mine by 2,300-volt powerlines from a transformer station about 5 miles northwest. Stepdown transformers at the mine plant and at the underground station convert the power to 440, 220, and 110 volts. Electric power is used at the mine for mine plant and underground lighting, blasting, and to operate shop equipment and the ventilation fans.

Dynamite consumption during October, November, and December 1955 averaged 19,554 pounds per month for mining and 2,329 pounds per month for development. Dynamite consumption for mining averaged 2.64 pounds per ton of ore produced during the 3 months.

SURFACE PLANT

The surface plant consists of a mine office and change-house building, a repair shop, a compressor house, and a fuel-storage building. All are frame covered with corrugated sheet metal. The mine office building contains a first-air room, a lamproom, and a modern dry room, with showers and clothes lockers for the crews. A well-equipped shop permits most equipment repairs to be made at the mine. A sample room at the mine shop building contains equipment to crush and pulverize mine samples. Fuel oil, lubricating oil, and grease are stored in a separate building. The surface explosives magazine is about 500 feet north of the adit portal. It has a wooden floor, is ventilated, and is kept locked at all times. The electric-blasting-cap magazine is a wooden-floored, 6- by 6-foot wooden building. It is well ventilated and kept locked. Danger signs are displayed prominently at both magazines. A mine telephone system connects the office with the shop building, underground mine shop, and center and northwest ore chute stations on the haulage level.

Compressed air is supplied by two Ingersoll-Rand, Gyro-Flo, 600-c.f.m. rotary compressors. Waster is piped to the buildings and underground from a 3,000-gallon steel storage tank enclosed in an insulated, corrugated-steel building. Water is hauled in a 1,500-gallon tank truck from a well 6 miles to the west.

Two-way shortwave radio contact is maintained between the company office in Moab and the mine office. Radio contact with either office can be made with a similar radio set mounted in the superintendent's automobile.

PRODUCTION RATES, PERCENTAGE OF RECOVERY, SAMPLING, AND PLAN OF PILLAR RECOVERY

Production Rates and Percentage of Recovery

Maximum effort on production from the Big Buck mine was stressed beginning in April 1955. Rate of production increased as the number of rooms were opened and operational difficulties smoothed. Some of the equipment had to be built or modified and personnel trained in its use. Utex Exploration Co. produced ore under contract from the Big Buck 8A and 9 claims through January 1956 while driving southeast to make the ventilation connection between the Mi Vida and Big Buck mines. During the final quarter of 1955, production from the Big Buck mine averaged 9,369.99 tons of ore per month. Of this average, Standard Uranium Corp. produced an average of 7,393.67 tons per month. Production cost data for this same period is tabulated at the end of this report. During January and February 1956, Standard Uranium Corp. increased production to 7,848.82 and 10,503.73 tons, respectively. The steady increase in production from October 1955 through February 1956 is believed to be due principally to the use of the Eimco 105 tractor with the Gismo loader beginning in November 1955, the installation of the 4-drill jumbo in January 1956, and the assignment of the mine crews to permanent shifts in February 1956.

To emphasize how the increased production is reflected in the labor performance figures for February 1956, as compared with the averages for the final quarter of 1955, the mine labor force for the two periods is tabulated in table 1, showing the man-hours per ton produced and tons produced per man-shift for the general classifications of stoping, haulage on the adit level, equipment maintenance, and general labor.

Labor man-hours that contributed directly to drilling, blasting, roof bolting, scaling and transportation of ore in the stopes and on the haulage level equaled 0.477 for the final quarter in 1955 and 0.337 for February 1956. The average of tons produced per man-shift for the same labor equaled 16.76 for the final quarter of 1955 and was increased to 23.76 for February 1956.

The Big Buck ore body is now being mined on the advance. Under ideal conditions where the ore is continuous in thickness and grade and there is no variation in the room-and-pillar arrangement, the percentage of ore extraction on the advance would be about 64 percent, with 36 percent remaining in the pillars. True percentage of extraction will vary to suit actual conditions encountered. Irregularity in pillar size, irregularity in size and layout of rooms or haulageways, as in the vicinity of the center ore pass, local variations in continuity of ore, as in local areas of waste or where the ore assumes unusual variations in height, pillar arrangement when approaching the limits of the ore body, and the expediency of not following this layout plan where the mining problem changes are all factors that will affect the actual percentage of extraction on the advance.

TABLE 1. - Labor performance data for final quarter of 1955 and February 1956

Tons produced

Final 3 months, 1955	February 1956
7,393.67	10,503.73

Occupation	Man-hours per ton		Tons per man-shift	
	Final 3 mos. 1955	Feb. 1956	Final 3 mos. 1955	Feb. 1956
Stoping:				
Drillers, scalers, roof bolters, powdermen, Gismo operator	0.393	0.275	20.37	29.10
Haulage, adit level:				
Tramming crew	.084	.062	94.71	129.68
Equipment maintenance:				
Mechanics, electrician, serviceman..	.190	.139	42.18	57.40
General labor:				
Truck driver, dozer oper. grizzlyman, bull gang	.102	.084	78.07	95.49
Average of all labor	.769	.560	10.40	14.29

Underground Sampling and Estimation of Tonnage and Grade of Pillars

The areal extent and continuity of the Big Buck ore body, as established by surface exploratory drilling, preclude the necessity of consistent sampling of working faces within its established boundaries. Working faces are sampled when they approach the boundaries of the ore body or when the grade of a specific face is questioned. Most of the mine sampling is concerned with pillars.

A systematic program of pillar sampling is carried on as mining progresses. Knowledge of tonnage and grade remaining in pillars is vital, especially of those pillars to be recovered during the final phase of pillar extraction. The engineer takes 4 to 6 vertical chip samples of each pillar and plots the pillar size with sample locations and analyses on a sample map. For an average-size pillar, approximately 20 by 50 feet square, 4 samples are taken, 1 on each corner of the pillar. Where pillars are much longer, one additional sample is taken at the center of each of the longer sides. Because of the uniformity of the ore, this number of samples is sufficient for ore-grade estimates. The samples are taken of the full height of the ore. Where visual inspection of a pillar face indicates a stratum of waste at the top or base of the pillar, the thickness of this stratum is sampled separately. Where a very high grade thin streak of ore is noted visually in the face, the streak is omitted from the sample. For convenience in sample handling, the higher pillar faces are divided into two vertical sections, each sampled separately and later weighted with their lengths to compute the average grade at the point sampled.

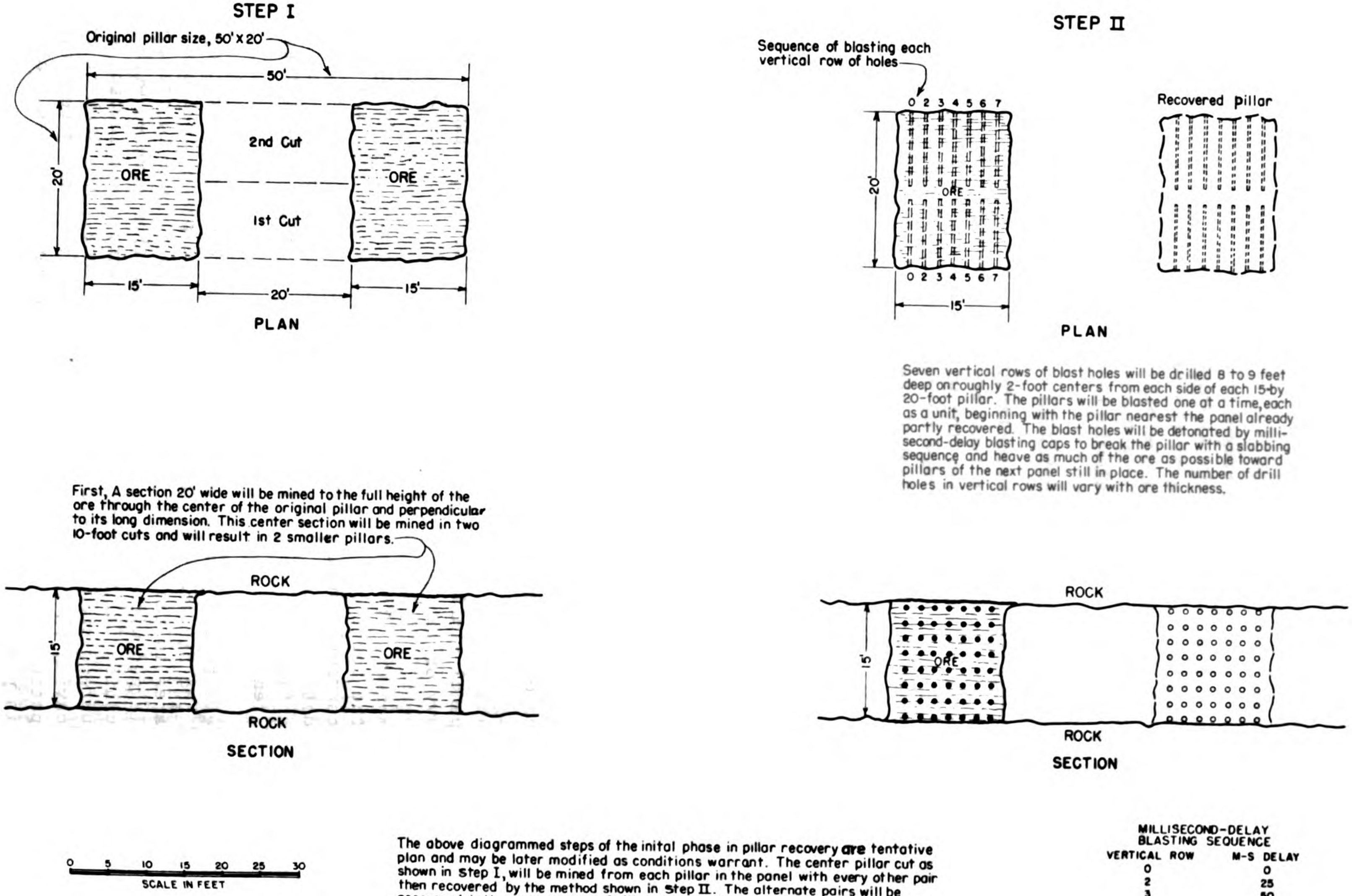
Samples are crushed with a 6-inch jaw crusher and pulverized to about minus-80-mesh in the sample room in the mine shop building. Samples are radiometrically assayed on an Eberline Ore Analyzer at the mine office to spot-check the U_3O_8 content. Samples are later sent to a laboratory for chemical determination of percent U_3O_8, V_2O_5, and $CaCO_3$.

The tonnage and grade of each pillar are computed as mining progresses. If the lengths of the samples from one pillar vary, the average percent of U_3O_8, V_2O_5, and $CaCO_3$ is obtained by weighting the assay value of the samples with their respective lengths. When the lengths of the samples from one pillar are near equal, the average grades are obtained by arithmetical averaging. A tonnage factor of 14.0 cubic feet per ton of ore in place is used for tonnage calculations.

Plan of Pillar Recovery

The method of pillar extraction was a particularly important problem considered in planning development. Two stages of pillar recovery are planned. The first is to recover a maximum number of pillars while working within the stoped area, with final extraction accomplished in the second stage by working from beneath the stoped area. After room-and-pillar mining has established the limits of the ore body, pillar extraction will be initiated by a method of systematic retreating to the incline. Beginning at an end panel, a panel consisting of a row of pillars perpendicular to the long dimension of the ore body, a section 20 feet wide will be mined through each pillar in the panel to the full height of the ore and at right angles to their long dimensions. These center sections will be mined by breaking two 10-foot rounds, using the same method of blasting now practices. This will result in pairs of smaller pillars, each about 15 by 20 feet in plan (see fig. 22). Beginning with the pair at the end of the panel, vertical rows of blast holes will be drilled on about 2-foot centers from the 15-foot sides of each. The smaller pillars will be recovered one at a time, but each will be broken as a unit. The vertical rows of blast holes will be detonated by millisecond-delay electric blasting caps to break each pillar with a slabbing sequence. After the outer pair have been recovered, the ground will be allowed to cave and stabilize. Little is known or will be known of the caving characteristics of the ground until this initial work is done. Because of the interbedded mudstone overlying the ore, company management believes that caving will occur gradually, continuing until a natural arch is formed. However, the resulting span may stand for some time. Pillar recovery will then progress toward the center of the panel similar to the recovery of the border pillars. Where the ground becomes too heavy or the span too wide for safety, the next inside pair will be temporarily abandoned. It is now believed that every other pair of pillars can be recovered in this manner. The more ore that can be recovered safely from the stope level, the cheaper the total recovery will be. Pillar measurements and sampling data, collected concurrently during the period the mine is being opened on the advance, will be used to determine the tonnage, grade, and value of the ore remaining in each pillar temporarily abandoned. Before abandoning a pillar, it will be wrapped with some type of fence wire.

Work will then progress to the panels nearer the incline, keeping an exit open to the incline. Ore from the pillars will be transported to ore passes in areas remaining open. Before an area in the vicinity of an ore pass is allowed to cave, the ore pass will be tightly lagged with heavy timber, pinned, and then covered with a thick layer of waste to cushion falling rock. As pillar recovery moves inward, a checker-board pattern of unrecovered pillars will remain in place. The lack of definite information on the caving characteristics of the ground precludes determining in advance the system or pattern of pillars that will be recovered or those that will be left temporarily in place.



First, A section 20' wide will be mined to the full height of the ore through the center of the original pillar and perpendicular to its long dimension. This center section will be mined in two 10-foot cuts and will result in 2 smaller pillars.

Seven vertical rows of blast holes will be drilled 8 to 9 feet deep on roughly 2-foot centers from each side of each 15-by 20-foot pillar. The pillars will be blasted one at a time, each as a unit, beginning with the pillar nearest the panel already partly recovered. The blast holes will be detonated by millisecond-delay blasting caps to break the pillar with a slabbing sequence and heave as much of the ore as possible toward pillars of the next panel still in place. The number of drill holes in vertical rows will vary with ore thickness.

The above diagrammed steps of the inital phase in pillar recovery are tentative plan and may be later modified as conditions warrant. The center pillar cut as shown in Step I, will be mined from each pillar in the panel with every other pair then recovered by the method shown in Step II. The alternate pairs will be recovered in the second phase of pillar recovery by undercutting and caving from a system of subdrifts.

MILLISECOND-DELAY BLASTING SEQUENCE

VERTICAL ROW	M-S DELAY
0	0
2	25
3	50
4	75
5	100
6	125
7	150

Figure 22. - Plan of recovering a pillar in first stage of recovery working from stope level, Big Buck mine, San Juan County, Colo.

Original from THE OHIO STATE UNIVERSITY

Work on the second phase of pillar recovery can begin when an area on the stope level has been temporarily abandoned. The ore passes will be timbered into 2 compartments, manway and ore shute, working from the haulage level to a point about 20 feet below the stope level. There a small station will be cut and a series of subdrifts driven out under the pillars. These subdrifts will not be driven in any special pattern but in directions that permit accomplishing the job with the minimum driving distance. Comparison of the value of ore remaining in a particular pillar as against the estimated cost to drive under and extract the pillar may possibly exclude some small pillars at the extremities of the ore body from consideration. When a subdrift has been driven under a pillar, a raise will be driven from the drift to near the base of the pillar expanding the raise near the top like an inverted funnel. Where the pillars are longer in one dimension this raise may also be similarly elongated. A series of long holes will be drilled up and fanned out into the bottom of the pillar. Blasting will break the cap and start the pillar moving downward. The ore will be transported to the ore-chute by scrapers until sampling shows that all of the ore has been extracted. Where an area around a pillar has been greatly enlarged and caving and arching has placed considerable weight on it, the pillar should begin to crush. It is hoped that crushing will help the caving action. The caved waste around the pillar should keep the pillar from crushing outward, and it is anticipated that the fence wire wrapped around the pillar will help the pillar to cave into the raise as a unit and keep dilution to a minimum.

In driving the subdrifts, company management now is considering a distance of about 10 feet from the back of the subdrift to the bottom of the pillar to be caved. How much undercutting will have to be done is not known at this time.

MINING METHODS IN THE DISTRICT

Principal production in the Big Indian mining district has come from the basal member of the Chinle formation, although some production has come from the Cutler formation. Many of the Chinle ore bodies are similar to the Big Buck ore body, although some are more irregular and thinner and some, as at the neighboring Mi Vida mine, have averaged thicker and larger.

Of the 7 other large operations along a 5-mile extension of the escarpment bordering the southwest side of Big Indian Wash, 5 have been developed by vertical shafts and 2 by inclines. The Mi Vida mine is the oldest producer in this immediate area, producing uranium ore since December 1952. Three mines are in development stages.

For the most part, vertical shafts are being sunk nearest the lowest extension of the ore bodies within property boundaries. Underground development has been both within the ore and beneath the ore. Track haulage is used where the main haulage levels are beneath the ore. The ore bodies are developed by a system of parallel haulageways driven to the property boundaries and a system of transverse haulageways that divide the ore bodies into panels. Scrapers are used to move broken ore from the stopes to chute installations when the main haulage level is beneath the ore. Scrapers or diesel haulage units are used where the main haulageways are within the ore. One ore body, developed into panels, is being experimentally mined by a system of retreat mining similar to long walling. Some of the mines are using a regularly spaced room-and-pillar system, with rooms ranging from 7 to 20 feet wide. Complete ore extraction is an important problem in every operation.

VENTILATION

The Big Buck mine workings are ventilated mechanically. Fans force fresh air into working areas where natural ventilation would not be adequate. Utex Exploration Co. and Standard Uranium Corp., through a working agreement, drove connecting entries between the Mi Vida and Big Buck mines. This interconnection provides two openings between the Big Buck workings and the surface, which is a provision of the General Safety Orders issued by the Industrial Commission of the State of Utah and provides a natural air course between the two mines for ventilation. Natural ventilation is not adequate to remove diesel exhaust-gas contaminents or to reduce the radioactive concentration of radon gas daughter elements to safe amounts in the mine atmosphere.

A 6-foot-diameter, low-pressure, 30,000-c.f.m.-capacity fan is mounted at wooden ventilation doors midway in the incline. This fan, which is driven by a 20-hp., 440-volt electric motor, is operated 24 hours. The fan can be operated to intake, moving fresh air through the portal of the adit and forcing it up through the incline and into the stoping area, or it can be reversed to move the air from the stopes through the haulageway. Blasting is done only at the end of the night shift, which assures ample time for the fan to remove all powder smoke and gases before the day shift starts. During the winter months, in periods of cold weather, the fan is reversed between 1:00 a.m. and 8:00 a.m. to let the warmer mine air assist in keeping the waterline in the adit from freezing.

A 2-stage, Joy, Axivane blower, model 1000 series, rates at 3,450-c.f.m. capacity and driven by a 15-hp., 440-volt electric motor, is mounted near the back of the haulage level at its intersection with the incline. This blower courses air through 15-inch metal ventilation tubing to either the northwest or southeast haulage drifts. Another blower of this type and a similar, though smaller, 5-hp. blower are used as auxiliaries in the stoping area to course air from the main air course through 15-inch ventilation pipe to where men are working in deadend rooms. When stoping has progressed farther from the main underground aircourse, the company plans to use canvas brattices to direct the main ventilating air currents nearer the working places where needed.

The safety engineer takes periodic radiometric samples of the mine air at working places to determine the atmospheric concentration of the immediate daughters of radon gas. Mine air is sampled at least once a month, and the computed concentrations of radon gas daughter elements are recorded with the date of sampling, description of the area sampled, and description of the ventilation in that area. The above information for each sample is tabulated on a standard record form for review by the State mine inspector, as required by an amendment to the General Safety Orders, effective January 1, 1956, issued by the Industrial Commission of Utah. This amendment states

> The atmospheric concentration of the immediate daughters of radon should not exceed 300 MMCL (micromicrocuries per liter) as determined by a field method acceptable to the State Bureau of Mines (Industrial Commission) and every operator shall make a reasonable effort to approximate said standard.

The mine air is sampled with a hand-operated vacuum pump and 1-inch-diameter millipore paper sample filters placed on the pump intake. The intake volume rate of the pump, in liters of air per minute, is standardized by turning the hand crank a predetermined number of revolutions per minute. The pumping time is recorded accurately to determine the total volume of air. Dust particles, to which the daughter elements of radon gas adhere, are impinged on the sampling filter. The sample filters are tested radiometrically on a Juno, model 3, survey meter. By using two standardized graphs, the number of mico-microcuries of radon gas daughter elements per liter of air that were present in the mine atmosphere at time it was sampled can be computed.

All diesel-operated equipment used underground is equipped with exhaust-gas conditioners to absorb some of the toxic gases and remove most of the smoke and irirtating constituents from the exhaust gases. The Eimco, 105 tractor, the Caterpillar, HT-4 front-end-loader, and the scout car are all equipped with dry catalytic-type conditioners; the Allis-Chalmers, HD-5, tractor, and the Mancha locomotives are equipped with water-type conditioners. On all equipment, exhaust lines between the manifolds and the conditioners are wrapped with asbestos tape to maintain the heat of the exhaust gas and thereby increase the efficiency of the conditioner and as a safety precaution for personnel against burns. A colormetric carbon monoxide gas detector is used to test the mine atmosphere for possible carbon monoxide concentrations when diesel equipment is operated temporarily away from an air course.

Ventilation on the main haulage level will be greatly improved when the southeast heading has been extended to intersect the nonoperating North American shaft. Similarly, ventilation within the stope area will be improved when the connection is made with the North American workings (see fig. 23). The elevation of the collar of the North American shaft is about 272 feet above the stope level of the Big Buck mine and 380 feet above the portal of the Big Buck adit. When the connections are made, the mechanical ventilation system will be modified to utilize this new opening.

MINE DRAINAGE

Virtually no underground water is encountered in mining. There is a slight seepage in a few areas on the stope level during periods of melting snows but the amount presents no drainage problem.

LABOR CLASSIFICATIONS, WAGES, AND INCENTIVE BONUS SYSTEM

Job Descriptions and Wages

Standard Uranium Corp. employs two shifts at the Big Buck mine, which work from 8:00 a.m. to 4:00 p.m. and from 5:00 p.m. to 1:00 a.m. The crews do not change shifts. The wage differential for working on the night shift is $0.06 per hour. Each man in a crew is specialized in his particular job but can be shifted to other work should it become necessary. Other than the supervisory staff, 38 men are now employed at the Big Buck mine, 23 men on the day shift and 15 on the night shift. Thirty-six men are paid at hourly wage scales, which may be either the hourly base wage established for each particular job classification or an amount equal to the sum of the hourly base wage plus a fluctuating increment calculated each pay period and awarded under an incentive bonus program. The bonus hourly increase is applied only to those hours that are accredited to ore production. Two additional miners working on the day shift are driving the southeast haulage drift under contract. The number, classifications, and hourly base wage scales are listed in table 2.

Eleven men on each shift are directly engaged in mining operations, such as drilling, blasting, roof bolting, scaling, and transportation of the ore from the place it is broken to the surface ore bins. Nine of these work on the stope level. Three men, who work on the stope level on the day shift, are charged with making the back and working faces safe by roof bolting and scaling. Their counterparts on

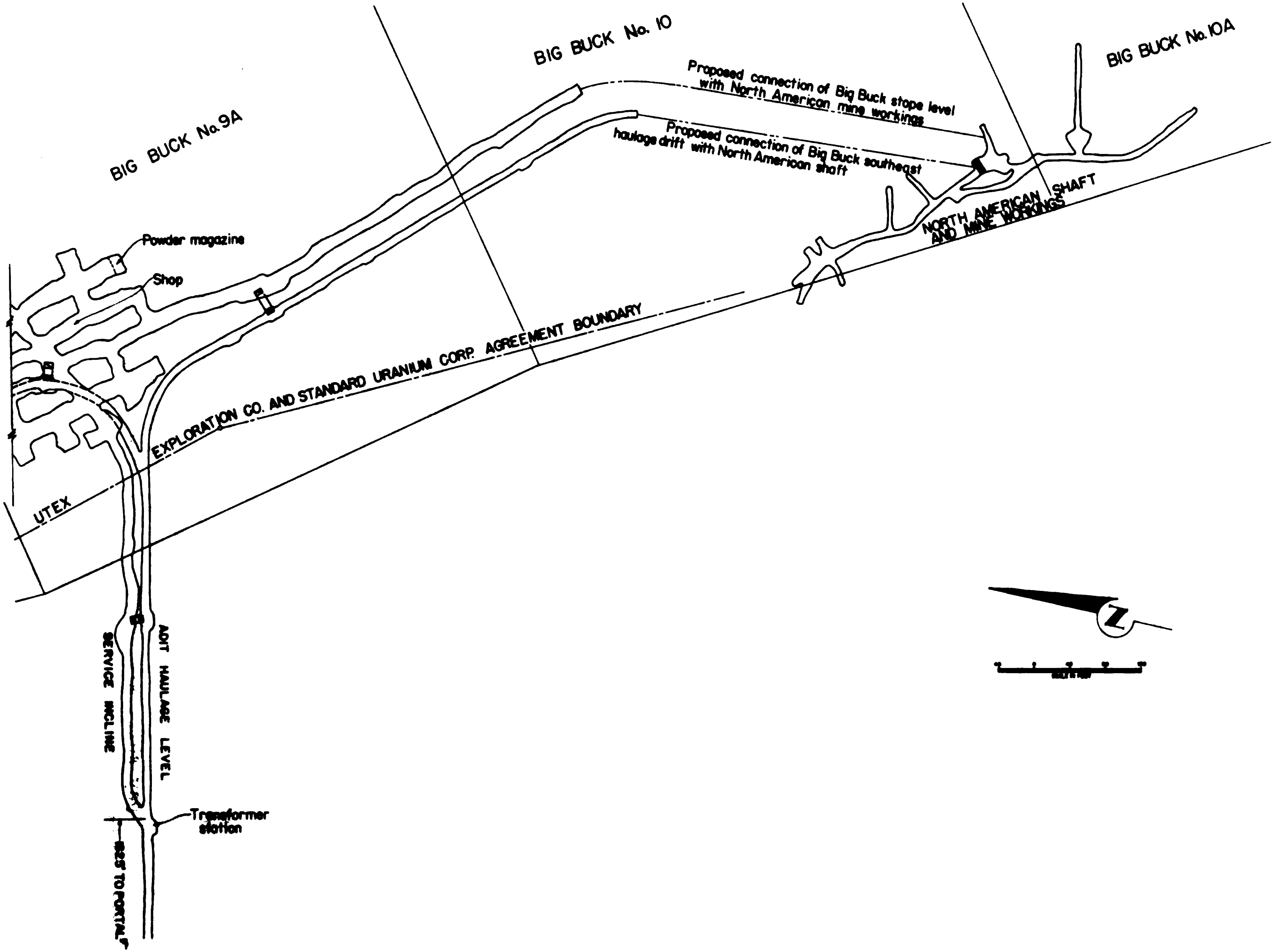

BIG BUCK No. 9A
BIG BUCK No. 10
BIG BUCK No. 10A
Proposed connection of Big Buck stope level with North American mine workings
Proposed connection of Big Buck southeast haulage drift with North American shaft
NORTH AMERICAN SHAFT AND MINE WORKINGS
Powder magazine
Shop
EXPLORATION CO. AND STANDARD URANIUM CORP. AGREEMENT BOUNDARY
UTEX
ADIT HAULAGE LEVEL
SERVICE INCLINE
Transformer station
1825' TO PORTAL
N

Figure 23. - Plan map, underground workings, Big Buck and North American mines, showing proposed ventilation connections, San Juan County, Utah.

the night shift are the three powdermen who load drillholes for blasting at the close of the night shift. The four men classified as general miners are those men who are driving the southeast heading on the stope level to connect with the workings of the North American shaft. The nippers bring the underground crews the necessary supplies and equipment and can substitute as drillers, roof bolters, or scalers if needed. The serviceman services and fuels all underground equipment at the underground shop on the night shift, keeping fuel oil, lubricating oil, and grease supplied at the service area. The truck driver hauls water and supplies to the mine and mine camp, and the bulldozer operator maintains roads, removes snow from roads, and works on the waste dump. The bulldozer operator also assists the mechanics in maintaining equipment. Three men on the bull gang do any general work either on the surface or underground or at the mine camp. Underground, they repair track, extend air and water pipe, move fans, repair ore chutes, or do any other necessary maintenance work.

TABLE 2. - Number, classifications, and hourly base wage scales of employees at Big Buck mine

Labor classification	Base hourly rate	Number of men employed		
		Day shift	Night shift	Total
Gismo-loader operator	$2.30	1	1	2
Mechanic	2.20	2	2	4
Electrician	2.20	1		1
Drill-jumbo operator	2.15	2	2	4
Roof bolter	2.15	2		2
Scaler	2.15	1		1
Powderman	2.15		3	3
Nipper	2.15	1	1	2
Miners, general[1]	2.15	2	2	4
Motorman, adit haulage	2.15	1	1	2
Dozer operator, surface	2.15	1		1
Truck driver	2.00	1		1
Serviceman, underground	1.95		1	1
Engineer's helper	1.90	1		1
Motorman helper	1.75	1	1	2
Grizzly operator	1.75	1	1	2
General labor, bull gang	1.75	3		3

[1] These 4 men are advancing the southeast heading on the stope level on a 2-shift basis and are included in the incentive bonus program.

The contract miners who are driving the 6- by 8-foot southeast haulage drift are paid $10.00 per foot of advance. The company provides all supplies and equipment. The contract price includes laying track and installing air, water, and ventilation piping. Working on a 6-day week, they actually receive more than $10.00 per foot, considering the overtime pay.

Incentive Bonus System

To stimulate production, the company in August 1955 initiated an incentive bonus program that is based on mine production during each pay period. This program affects all personnel at the mine, other than the supervisory staff, relative to the hours each has worked that are accredited to production. From past experience in room-and-pillar mining and from earlier production rates at the Big Buck mine, the superintendent calculated that on a straight day's-pay basis, a 25-man crew working 2 shifts could be expected to produce an estimated 10 tons per man-shift. Using an average day's pay for the entire crew, an average day's-pay labor production cost was computed at $1.80 per ton. The incentive bonus system is based on this figure and the tons produced during each 2-week pay period. In effect, the men who take part in the program split proportionately a percentage of the difference between the total straight-time earnings of the entire crew calculated at their individual established hourly wage rates and the theoretical labor cost of producing the period's production calculated at $1.80 per ton.

Tons produced equals the total tonnage of ore and waste excavated from the stope level: The tonnage of ore shipments is taken from the settlement-sheet records of the periods, and tons of waste is converted from cars trammed. The gross bonus credit for a pay period is the product of the tons produced times $1.80, minus the monetary total of the straight-time wages of the entire crew calculated at their individual straight-time hourly wage rates. The gross bonus credit reflects not only the incentive of the crew to increase production but also the incentive of management to supply and equip the mine in a manner that assists in making the increased production possible. To compensate the costs incurred by the company for new-type equipment, for experimenting and modifying equipment, and for general improvements in mine operation, the company credits itself with a 25-percent share of the gross bonus. The net bonus credit, which is split among the crew, is therefore 75 percent of the gross bonus credit. To allow those men who are more directly responsible for the increased production to share greater in the bonus earnings, the net bonus credit is proportioned among the crew according to a rating system that classifies each man according to his job. The men considered most responsible for increasing the production are classed in unit 3. These consist of men who work in the stopes - drilling, blasting, scaling, roof bolting, mucking, and nipping. Unit 2 classification is the haulage crew, mechanics, electrician, and serviceman. Unit 1 is the bull gang, grizzlymen, and truck driver. The net bonus credit is also proportioned among the crew according to hours each has worked during the period that are accredited to production. The unit classification of each man is multiplied by his straight-time hours accredited to production, the product of which is designated as his hour-units. The total hour-units of the entire crew is divided into the net bonus credit to arrive at the bonus per hour-unit. The bonus per hour-unit figure is then multiplied by the unit-classification rate of each man to arrive at his bonus increase rate per hour. The bonus increase rate is added to the base hourly wage of each man to give the new bonus rate per hour. This new rate is then used to compute the individual earnings for this period for time on production.

Table 3 shows the method used by the company to determine the bonus rate per hour for the pay period of November 7-20, 1955. For convenience, this table groups the men into their various work classifications rather than listing each man separately. Also, the tabulation is concerned only with those hours worked that are affected by the incentive bonus program.

Because every man in the crew shares in the incentive bonus program, each has an interest in production. This mutual interest keeps the crews working as a unit. A mechanic repairing a tractor is just as interested in getting that piece of equipment back into production as is the man who uses it. The tramming crew will make certain that a Gismo operator will not have to curtail haulage on the stope level because an ore pass is full.

TABLE 3. - Example of bonus rate calculations, pay period November 7-20, 1955

Tons shipped during period	4,026.135
Tons waste removed from stope	348.62
Total tons	4,374.755

Total tons x $1.80 per ton	$7,874.56
Less base payroll	$5,696.00
Gross bonus credits	$2,178.56
Net bonus credit, 75%	$1,633.92

Item	Labor classification	No. men	Base hourly wage	Total hours worked1/	Total overtime worked, hours	Total base wages2/	Job unit class	Total hour units	Bonus increase, rate/hour	Bonus, rate/hour	Gross earnings
1	Gismo operators	2	$2.30	176.5	32.5	$405.95	3	529.5	$0.801	$3.101	$597.72
2	Mechanics3/	4	2.20	354.5	98.5	779.90	2	709.0	.534	2.734	1,103.85
3	Mechanic3/		2.40	62.0	22.0	148.80	2	124.0	.534	2.934	214.18
4	Electrician	1	2.20	96.0	24.0	211.20	2	192.0	.534	2.734	295.27
5	Drill-jumbo operators	4	2.15	314.0	26.0	675.12	3	942.0	.801	2.951	964.98
6	Roof bolters	2	2.15	152.0	8.0	326.80	3	456.0	.801	2.951	460.36
7	Scaler	1	2.15	80.0	8.0	172.00	3	240.0	.801	2.951	247.88
8	Powdermen	3	2.15	224.5	8.5	482.68	3	673.5	.801	2.951	675.04
9	Nippers	2	2.15	120.0	8.0	258.00	3	360.0	.801	2.951	365.92
10	Miners, general stope	2	2.15	153.0	1.0	328.96	3	459.0	.801	2.951	452.98
11	Motormen	2	2.15	152.5	8.5	327.88	2	305.0	.534	2.684	420.72
12	Dozer operator4/	1	2.15	64.0	8.0	137.60	2	128.0	.534	2.684	182.51
13	Truck driver	1	2.00	109.5	37.5	219.00	1	109.5	.267	2.267	290.74
14	Serviceman, underground	1	1.95	73.0	9.0	142.35	2	146.0	.534	2.484	192.51
15	Motorman helpers	2	2.15	105.0	9.0	225.76	2	210.0	.534	2.684	293.90
16	Do.	1	1.75	48.0	8.0	84.00	2	96.0	.534	2.284	118.77
17	Grizzly operators	2	1.75	144.0	0	252.00	1	144.0	.267	2.017	290.45
18	General labor - bull gang	1	2.15	96.0	24.0	206.40	1	96.0	.267	2.417	261.04
19	Do.	2	1.75	152.0	32.0	266.00	1	152.0	.267	2.017	338.86
20	Mechanic helper5/	1	1.90	24.0	24.0	45.60	2	48.0	.534	2.434	87.62
	Total	35		2,700.5	396.5	$5,696.00		6,119.5			$7,855.30

Bonus per hour-unit $= \frac{1633.92}{6119.5} = 0.267$

Bonus increase rate per hour

Job class 1 = 0.267
Job class 2 = 0.534
Job class 3 = 0.801

1/ Total hours worked as accredited to production; includes overtime hours.
A few item totals vary slightly from straight calculations due to 1/2 hour worked by individuals in classifications.
2/ Computed on total hours at straight time; overtime and night differential pay not included.
3/ One mechanic paid $2.40 per hour for 62 hours supervisory work. Remaining time in item 2.
4/ Dozer operator worked assisting mechanics; changed from class 1 to class 2 these hours.
5/ Engineer's helper, worked assisting mechanics.

SAFETY METHODS, FIRST-AID ORGANIZATION, AND FIRE PREVENTION

The Utex Exploration Co. and Standard Uranium Corp. have jointly employed an experienced safety engineer. The duties of this engineer are to assist in promoting safety at both mines and to administer first aid if necessary. He makes regular and frequent safety inspections of all underground operations and surface installations at both the Mi Vida and Big Buck mines. He is experienced in rendering prompt and correct emergency care in case of mine accidents. The safety engineer lives at the Standard Uranium Corp. camp in a company-owned trailer and is available for emergency calls day or night.

An ambulance owned by Utex Exploration Co. is always available for ready use by either company should an occasion arise. The main first-aid station, containing a complete stock of first-aid supplies, and a hospital bed are at the Mi Vida mine and are maintained by both companies. The ambulance is equipped with two hospital stretchers, blankets, first-aid kit and an E & J resuscitator unit. The resuscitator unit can also be used as an inhalator or aspirator.

Easily accessible, well-stocked, first-aid cabinets and two stretchers, an Army canvas-type and a Jarret splint-type, are kept in a small first-aid storeroom in the Big Buck mine office building. Underground a first-aid station is maintained with a splint-type stretcher and first-aid cabinets.

"Danger, No Smoking" signs are well displayed on the dynamite and electric blasting-cap magazines on the surface and at the dynamite magazine underground. "Danger, High Voltage" signs are displayed at the underground transformer station. Reflector-type signs, hung on the haulage level, point to man-refuge stations to protect personnel from passing trains. Within the stoping area reflector-type exit signs indicate the directions to the surface through both entries. Pyrene-type and carbon dioxide-type fire extinguishers are installed at points handy on the surface and underground. The company supplies safety goggles and plastic cap visors to the crew and stresses their use when working conditions present a potential eye hazard. The wearing of hard-toed boots and shoes is encouraged. Respirators are supplied by the company as a precaution against atmospheric dust. Diesel fuel oil, lubricating oil, and greases are stored on the surface in a separate building to lessen the hazard of fire.

A complete record of all mine accidents is maintained by the safety engineer; he submits monthly and annual accident reports to the company officials, reporting the accident-frequency rates and accident-severity rates during the reporting period. To assist in promoting safety, a competitive safety contest has been launched between the Mi Vida and Big Buck operations. Large signs are hung conspicuously at the mine offices that show the number of days worked at each mine without a lost-time accident. Safety meetings, conducted by the safety engineer, are held monthly for all personnel.

SUMMARY OF COSTS

Name of mine: Big Buck

Mining method: Room-and-pillar on advance

Ore mined, tons:[1] 22,181.02

Period covered: Oct. 1-Dec. 31, 1955

1. Direct costs per ton of ore:

	1. Labor[2]	2. Supervision	3. Drill steel and bits	4. Power and elec. supplies	5. Explosives	6. Diesel fuel, oil and grease	7. Other supplies	8. Total
Development, in rock[3] ...	$0.13	$0.01	$0.01		$0.09		$0.04	$0.28
Mining	1.15	.25	.45	$0.19	.73	$0.31	.26	3.34
Transportation, adit level	.24	.02				.02		.28
Equipment maintenance	.63	.11					.59	1.33
Total	$2.15	$ .39	$ .46	$ .19	$ .82	$ .33	$ .89	$5.23

2. Indirect costs per ton of ore, same period:[4]

Item	Cost per ton
Engineering and sampling	$0.09
Service truck, operation, maintenance, and depreciation	.24
Depreciation, mining equipment	.74
Depreciation, mine and camp buildings	.09
Payroll taxes and workman's compensation	.22
Miscellaneous	.46
Administrative costs, Moab office	.25
Total	$2.09

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[1] Not included, 5,928.96 tons mined under contract by Utex Exploration Co.

[2] All general labor, both surface and underground, distributed by company to mining, transportation, or equipment maintenance.

[3] Driving the haulage level southeast and driving the south ore pass.

[4] Excludes depletion allowance and amortization.

Name of mine:	Big Buck	Mining method:	Room-and-pillar on advance
Ore mined, tons:[1]	22,181.02	Period covered:	Oct. 1- Dec. 31, 1955

3. Summary of direct costs in units of labor, power, and supplies:

	Development[2]	Mining and haulage	Total
A. Labor (man-hours per ton):			
Drilling, blasting, scaling		0.304	0.304
Roof bolting		.043	.043
Gismo haulage, stope level		.046	.046
Haulage adit level		.084	.084
Total labor, underground	0.038	.477	.515
Equipment maintenance			.190
General labor[3]			.102
Total, all labor			.807
Labor (tons per man-shift):			
Total labor, underground	211.49	16.76	15.33
Equipment maintenance and general labor			27.40
Total, all labor			9.91
Labor and supervision, percent of total costs:[4]			
Total labor and supervision	2.67	31.74	34.41
Equipment maintenance			14.16
Total, all labor and supervision			48.57
B. Power and supplies:			
Explosives (40 percent dynamite):			
Pounds per ton	0.31	2.64	2.95
Power, electric; ventilation:			
Hp. hr. per ton			1.15
Diesel fuel; compressors and all underground equipment:			
Gal. per ton			1.7
Supplies and power, percent of total direct cost:			
Underground	2.68	37.47	40.15
Equipment maintenance			11.28
C. Percent of total direct cost:			
Underground	5.36	69.21	74.57
Equipment maintenance			25.43

[1] Not included, 5,928.96 tons mined under contract by Utex Exploration Co.

[2] Computations based on tonnage produced during period.

[3] Principally surface.

[4] General labor costs distributed by company to mining, haulage, and equipment maintenance.

4. Development costs:

Direct costs to drive the first 2,300 feet of adit (1,625 feet 8 by 9 ft. in cross section and 675 feet 6 by 8 feet in cross section).

Item	Cost per foot
Labor[1]	$19.30
Explosives	3.30
Pipe, air and water	2.11
Track	2.40
Power and other supplies	9.60
Ventilation pipe	1.65
	$38.36

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[1] Labor paid at hourly rate for first 450 feet. Remaining distance driven under contract.